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Conceptual Integration of Digitalization and Servitization as Means to Introduce the Circular Economy

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Abstract. The Circular Economy (CE) can be implemented with different strategies. In this analysis, it is assumed that there is a desire to find a CE introduction strategy that leads to as rapid and environmentally friendly increase of resource-efficiency as possible. It is further assumed that an introduction strategy needs to take full advantage of other resource-efficiency concepts, societal trends, and developments. It is observed that the ongoing Digitalization and Servitization trends have been found to significantly affect each other, and as Digitalization impacts the possibility to make operations more resource-efficient, and Servitization means a change in the business model, it is assumed that those trends affect the incentives and possibilities for companies to develop Circular Solutions (CS) suitable for the CE, and that it is relevant to ask how. The purpose of this is to contribute to the development of a resource-efficiency concept that synthesizes Digitalization and Servitization, to contribute with suggestions on how to efficiently introduce the CE. It is asked; What measures may take advantage of the Digitalization and Servitization trends, and efficiently facilitate introduction of the CE? To find the answer a theory synthesis conceptual approach is used, and it is analyzed how Digitalization and Servitization trends can contribute to increasing resource-efficiency, and what implications these trends may have on a strategy for the development of CS and the introduction of the CE. The findings indicate that companies interested in enacting resource-efficiency measures and being important actors in the future CE, should have their main focus on business models that incentivizes development of CS, rather than on techniques that enables the development of CS. This further indicates that an efficient CE strategy should prioritize policies that give actors responsible for procurement and purchasing, incentives to 'servitize' their purchasing strategy.

Keywords. Digitalization, Servitization, Digital Platforms, Circular Economy

1. Introduction

Finding solutions to realize the Sustainable Society while simultaneously maintaining a high living standard is an important objective. But important as it is, finding these solutions are challenging and many environmental indicators are still continuously worsening [1], climate indicators in particular [2]. One part of handling this challenge could be to enact policies that increase resource-efficiency, thereby potentially being able to increase living standards without increasing environmentally damaging resource consumption, as "The potential for resource-efficiency is tremendous" [3]. One response to this is the ambition to introduce the CE, as this introduction is assumed to

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enable companies to create desired value with less material consumption over time. The CE can, however, be introduced with different strategies and a broader systemic approach to the CE has been called for [4]. In this analysis, it is assumed that there is a desire to find a CE introduction strategy that leads to as rapid and environmentally friendly increase of resource-efficiency as possible, while at the same time fulfilling other societal desires. It is further assumed that an efficient introduction strategy needs to take full advantage of, or adapt to, other measures that generate resource-efficiency. It is observed that the ongoing Digitalization and Servitization trends have been found to significantly affect each other [5] and as Digitalization impacts the possibility to make operations more resource-efficient, and Servitization means a change in the business model, it is assumed that those trends affect the incentives and possibilities for companies to develop CS suitable for the CE, and that it is relevant to ask how. The overarching purpose of this is to contribute to the development of a resource-efficiency concept that synthesizes Digitalization, Servitization, and CS. The primary purpose is also to contribute with policy suggestions regarding how to efficiently introduce the CE. This is important as e.g. Carlota Perez says: "It's all up to government. Companies are not going in the green direction because they don't need to—because they're making money with what they're doing." It is therefore asked; Which policy Measures could tie Digitalization, Servitization and CS development efforts together and support efficient introduction of the CE? To find the answer it is analyzed how Digitalization and Servitization can contribute to increasing resource-efficiency, and what implications this may have on a strategy for the CE introduction. The findings indicate that technology developments such as improved traceability, control of component lifetime, predictive maintenance, and transfer from hardware components to software, continuously increase the possibilities to cost-effectively develop CS. However, the findings also indicate that companies may have limited incentives to take advantage of these possibilities if they are using business models where they are remunerated for the Technology they supply. The findings further indicate that incentives to develop CS would increase if companies servitize their purchasing operations, and shift to business models where they remunerate suppliers for the Value they create, instead of the Technology they supply. This is important as it indicates that companies interested in enacting resource-efficiency measures and being important actors in the future CE, should have their main focus on CE incentivizing business models, rather than on 'circular' Technology solutions. This further indicates that an efficient CE strategy could be to prioritize policies that give actors responsible for procurement and purchasing incentives to shift business models, from paying for Technology, to paying for created Value.

2. Method

In the literature four major analysis methods for conceptual papers have been identified [6]. The 'theory synthesis' conceptual approach has been chosen as this paper aims to highlight benefits of synthesizing the concepts of Servitization, Digitalization and Circular Solutions, possibly taking steps towards a unified resource-efficiency concept, and it is analyzed:

- How can Servitization increase resource-efficiency?
- How can Digitalization increase resource-efficiency?

- How can Circular Solutions increase resource-efficiency?

Based on the findings it is then analyzed how different Measures could be taken to most 'efficiently' introduce the CE, i.e. an introduction of Measures that incentivize, adapt to, and take advantage of the Servitization and Digitalization possibilities, to generate resource-efficiency, and rapidly create more 'Value' (V) with less environmentally damaging 'Resource' consumption (R). That is, an introduction that rapidly increases the fraction *V/R* over a 'Circular' time-frame, i.e. a time-frame where benefits can be reaped from efficient reuse, maintenance and repair, upgrading, remanufacturing [7] and recycling of Material and Technology, i.e. from "Value Retention Processes" (VRP's) [8].

3. Theoretical Framework

Below is a description of how Servitization, Digitalization, Circular Solutions, The Circular Economy, Value, Resources, Market actors, Resource-efficiency, and Measures are defined.

3.1. Servitization:

Servitization can be viewed as a shift in focus from products and technological systems (defined as 'Technology'), to the 'Value', utilization of Technology is assumed to create. Completely changing the business model from buying products or making investments in Technology, to instead remunerating a supplier for created Value can be considered as the logical 'end station' of a Servitization process, and the resource-efficiency reasoning below is based on a situation where the Servitization process has gone all the way to the business model being completely changed, from the purchase of products, or investments in Technology, to remuneration for created Value, i.e results-based Product Service Systems (rPSS) [9].

3.2. Digitalization:

Digitalization is defined as improved utilization of information to measure, control, and optimize systems, i.e. utilization of Technology to increase the V/R-fraction, IT-fication, i.e. a shift from hardware, to software that can perform the same functions, and development and use of 'smart' products e.g. products that can communicate, e.g. geographical location, position and status.

3.3. Circular Solutions and the Circular Economy

Circular Solutions are defined as solutions that are designed for resource-efficient reuse, maintenance and repair, upgrading, remanufacturing, and recycling of material, components, and products, i.e. designed for VRP's.

3.4. Market actors

It is assumed that an efficient CE introduction strategy requires a systemic approach [4] and that as many Market actors as possible are incentivized to develop and utilize CS. Those actors are defined as actors within the 'Market' that benefit from created Value, or can contribute to the maximization of the V/R fraction:

- Primary recipient of Value ('Customers')
- Developer of Technology to be used for Value creation ('Developer')
- Users of Technology and Resources for Value creation ('Technology users', which could be 'Customers', 'Developers' or 'Third Parties')
- Any secondary third-party actors affected by Production or Product use, or are able to contribute with Resources for Value creation, or benefit from created Value ('Third Parties')

3.5. Value, Resources and Measures

Value is defined as a vector of all value-'terms' that Market actors may find desirable, e.g if the desired Value is 'good indoor climate', value-terms could be 'temperature', 'air quality', 'useful climate information', as well as anything that may have a positive impact on Third Parties, etc.

Limiting Resource utilization is defined as utilization of Resources that are indeed limited or carries a Sustainability cost, i.e. production and utilization of [most] goods, logistics systems, production systems, energy, and raw material. This vector of 'limiting resource terms' (lR) is to be minimized when creating Value, through the introduction of Resource-efficiency Measures.

Non-limiting Resource utilization is defined as utilization of Resources that are not limited, or carries a marginal, or low environmental cost. This could for example be utilization of Resources that otherwise would be 'idle', such as idle production tools, unutilized spaces, or of software that is powered by renewable energy. Utilization of e.g.idle industrial tools or vehicles carries an environmental cost, but if the alternative is to produce and utilize *new* tools or vehicles, the 'substitutional' environmental cost for utilization of 'idle' resources is significantly lower. The use of the vector of 'non-limiting resource terms' (nlR) is to be optimized rather than minimized, i.e. utilized to maximize Value/(limiting Resources), through the introduction of Resource-efficiency Measures.

4. How can Servitization increase resource-efficiency?

Numerous papers have been published discussing how PSS can increase resource-efficiency. It has, however, been argued that it is primarily the results-oriented rPSS variant that drives resource-efficiency [10] – "not because of the sustainability motivation, but rather as a result of the built-in business incentive for keeping costs low, thereby decreasing associated material use and impacts". A summary of the literature indicates that rPSS contributes to the increase in V/R by initiating several resource-efficiency enablers:

- It increases focus on *which* Value is desired, i.e. increases focus on creating only the 'correct' Value, and thus reduces resource consumption for activities that are not creating the 'correct' Value.

- Remineration for created Value and not for Technology, drives a broadening of the supplier view regarding which Technology and what Resources can be used as tools to create Value, from 'only' the 'original product' (which was previously the supplier's source of income), to 'the original product' in combination with other, in principle all other, globally available organizational, software and hardware resources, i.e. if you take it the farthest, a global ‘techno-organizational system’, which is the supplier's cost items when only remuneration is given for created Value.
- The incentives for innovative resource-efficient solutions increase as it becomes relevant to review how the entire global techno-organizational system can be used for Value creation. The development of digital platforms that coordinate all available ‘idle’ resources for Value creation is an example, such as AirBnB.
- When a supplier does not get remunerated for supplied Technology but only for the Value that is created, the resource-efficiency incentive is transferred from the recipient of Technology (the Customer) to the creator of Value. The total efficiency incentive then increases significantly and incentivizes both optimized selection of Technology and optimized use of the selected Technology, where e.g. Göteborg Energi has claimed that when their customers switch from buying energy to buying the product 'Indoor comfort', energy consumption decreases 17% on average.
- ‘Value’ is always created over a certain time, which drives the development of Technology adopted for utilization of resource-efficient VRP’s, i.e. CS, which is a crucial prerequisite for the introduction of the Circular Economy.

4.1. Servitization and resource-efficient competence utilization

When Technology is developed and utilized to create Value (V), different Market actors have different types of competence that can be used so that the choice, and the use, of Technology for Value Creation is maximally resource-efficient, i.e. so that the V/R fraction is maximized. Competences that can be utilized to maximize the V/R fraction are e.g. understanding of:

1. Which Value Customers want to maximize
2. What Resource consumption to minimize when creating Value.
3. How to select which Technology may maximize the V/R fraction
4. How use of selected Technology can be optimized for V/R maximization
5. How Technology VRP’s should be carried out to maximize the V/R fraction
6. How new/better Technology can be put into practical use as quickly and resource-efficiently as possible to continuously increase the V/R fraction

It is assumed that a systemic approach and the use of methods that effectively enable all Market actors to contribute with competence and Resources to all points 1-6 above, will maximize the V/R increase, i.e. methods that stimulate ‘co-creation’ [11] of Value. It is obvious that different actors can contribute different amounts to points 1-6, i.e. an effective utilization of the core competence of different actors will result in the largest increase in the V/R ratio.

It can be assumed that Customers can contribute the most with expertise in specifying which Value Customers want to maximize and which long-term Resources Customers want to minimize, i.e. 1 and 2.

Third parties can contribute with Resources that can reduce the total Resource Needs by offering Resources that otherwise would be idle, e.g. the resource 'vacant rooms' which is made available via e.g. AirBnB.

It can also be assumed that Developers can contribute the most with, at least, initial competence under points 5 and 6, if complex systems are developed and used to create Value, provided that Developers have a clear picture of which ratio V/R to maximize. It can also be assumed that Developers can contribute the most initial skills under points 3 and 4.

The above means that rPSS may incentivize better utilization of market actor core competence. With such an organizational approach, incentives are given to Developers to focus on their core competencies, i.e. to identify, develop and ensure effective Technology utilization to maximize the long-term V/R fraction, and for Customers to focus on their core competencies, i.e. to identify and specify the Value they want to increase and what Resource consumption they want to reduce.

5. How can Digitalization increase resource-efficiency?

Digitalization is increasing:

- Transparency and opportunities to compare different suppliers, which drives towards an economy with only ‘superstar companies’ [12]
- The ability to identify, measure and coordinate globally desired Value, and globally available Resources, potentially possible to utilize for the creation of this desired Value, i.e. enabling a systemic approach [4]
- Opportunities to measure created Value, Resource consumption, ‘system settings’, and to control Technology system settings in a direction that can increase V/R
- Opportunities to create and analyze information to identify, develop, optimize and use Technology more efficiently over time.
- Opportunities to monitor system and component location, position, status and origin, and to communicate this system status, which enables more efficient VPR’s
- IT-fication, which enables more efficient upgrading of Technology as software can be upgraded ‘from a distance’ and automatically

6. How can Circular Solutions increase resource-efficiency?

As for Servitization and PSS, numerous papers have been published discussing how CS can increase resource-efficiency, since CE pioneers such as Walter Stahel made his prize-winning product life factor publication [13]. Resource-efficiency studies from later CE scholars, which have complemented the work of Stahel and other CE pioneers such as Schmidt-Bleek [14], can often be viewed as PSS studies as well (which is one basis for the concept synthesizing work presented in this paper). A summary of the CS resource-

efficiency literature thus indicate that CS contributes to the increase in V/R by initiating several resource-efficiency enablers similar to the rPSS efficiency enablers. However, while PSS efficiency papers tend to highlight increased efficiency incentives, CS efficiency papers tend to highlight the practical efficiency implications of VRP's, and that the CE is resource-efficient over 'circular' time frames. Development of solutions that embrace the 3R principle [15] i.e. solutions that can Reduce material consumption, Reuse Technology, and can take advantage of Recycled components and material, and other VRP's, and still be able to create the same, or more Value, can in the short run be a resource consuming task. However, in the long run, it is assumed that resource savings from full utilization of the 3R principle, will outweigh the resource consumption required for development of the circular solutions.

7. How can Digitalization, Servitization and the CS concepts be synthesized?

Below is an analysis of how the three concepts Digitalization, Servitization and CS are connected to each other. Based on this analysis it is explored what policies may most efficiently take advantage of all resource-efficiency enablers for all three concepts, tie the concepts together and facilitate an efficient introduction of the CE.

7.1. Digitalization impact on Servitization

Digitalization increases both the incentives to pursue a Servitization process, as well as the opportunities to take advantage of Value proposals. The contribution of digitalization to increasing transparency and competition among companies, drives both Customers and suppliers to use increasingly resource-efficient business relationships. This, together with increased environmental requirements, incentivizes a Servitization process for resource-efficiency reasons.

The accelerating technological development continuously reduces the time that different technical systems can be used competitively. This increases the Developers' competence advantage in relation to Customers' competence regarding the opportunity to quickly and resource-efficiently learn to use newly developed Technology for Value creation. This drives business models and organizational forms where Developers have incentives to also use the developed Technology for Value creation, i.e. it increases incentives for Servitization, and for the development of systems that can be resource-efficiently upgraded when new better Technology is available, and in the long run, for development of CS.

The accelerating IT development increases the Developers' competence advantages regarding ability to rapidly introduce and benefit from newly developed Technology for practical application. A variant of the above competence advantage is opportunities for better risk assessment than Customers. Developers know which technology is 'in the tube' for practical application, i.e. have better insights into what Technology that could be possible to invest in. This increases the incentive for Customers *not* to make long-term investments in the ownership of Technology, but instead, focus on the payment of created Value, and letting professional Technology Developers choose, implement and use the Technology that is most resource-efficient for the day. This drives business models from Technology investments to the payment of created Value, i.e. Servitization.

Developers often have a competence advantage that arises through the opportunity to build and use a database of user information from many Customers and other Market

actors, for continuously more Value creation. The incentive for Developers to retain control and ownership of Technology is thus increasing.

The increased opportunities for machines and systems to communicate make it increasingly easier for Developers to both know system status and maintain systems remotely, and to continuously update systems with new software, thereby taking advantage of their competence advantage in terms of maintenance and upgrades. One reason for Tesla's success is that the car is, to some degree, designed as an Iphone, for continuous software upgrading [16].

The increased communication opportunities also increase the possibility for professional system coordinators to coordinate fleets of machines/actors/methods to maximize the total fraction V/R needs for a large group of Customers and Third Parties. This total 'system' V/R fraction can also be regarded as superior to the total fraction that can be achieved via 'business-to-customer' relations, which is described, for example, in the book 'Platform Revolution' [17]. It is not surprising that AirBnB is the world's largest supplier of beds, rooms, houses, castles, etc, where the opportunity to take advantage of otherwise idle resources (empty beds, rooms, etc) is just one of the platforms' competitive advantages. Presumably the most important factor that creates superior resource-efficiency over 'business-to-customer' solutions is that the value of platforms increases the more 'activity' that takes place via the platform. More activity often means that the value of the platform increases most if the Customer offers via the platform are 'free' and thus most interesting for a large group of Customers, such as 'free' search results from Google searches. The pressure to offer Customers something for 'free' puts a very strong resource-efficiency pressure on suppliers.

The above help to explain that RollsRoyce value proposition; 'purchase of 'traction'', as an alternative to 'purchase of aircraft engines' (the product 'PowerByTheHour', later further developed into 'CorporateCare') was one of the first Servitization processes where Servitization was taken to its logical consequence, i.e. when you only charge for the created Value (traction). Aircraft engines are very complex and the Developers' competence advantage in terms of creating a high V/R ratio over time is significant compared to aircraft owners who own and maintain engines.

The ongoing exponential technology development can also be assumed to lead to disruptive transitions from 'business-to-customer' sales of products, to payment for created Value via digital platforms. RethinkX, for example, estimates that the fossil car industry will collapse between 2022-2024, with a sharp transition from the purchase of cars to the purchase of 'Transport as a Service' (TaaS) via digital platforms [18].

Digitalization and Servitization are so intimately linked that "the service revolution and the information revolution are two sides of the same coin" [5]

7.2. Digitalization and Servitization connection to Circular Solutions

Taken together, the above reasoning leads to:

- Digitalization is driving Servitization as it e.g. increases the ability of Developers to utilize their competence to take maximum advantage of available global' Resources, to maximize the desired V/R fraction. This incentivizes the development and utilization of business models and organizational forms where suppliers are remunerated for their ability to create

Value, in contrast to models where suppliers are remunerated for supplied Technology.
- Incentives to develop and utilize Technology that is long-term resource-efficient for Value creation, which includes incentives to design products for efficient VRP's, i.e. Circular Solutions

Digitalization and Servitization thus both enable and incentivizes resource-efficient operations, and the development of Technology designed for VRP's, i.e. the crucial conditions for the CE. Any Measure that stimulates Digitalization and Servitization thus enable, and at least to some degree, stimulate the introduction of the CE, but it is of interest to analyze what Measure may most efficiently stimulate introduction of the CE.

7.3. Efficient concept Synthesizing Measures

Below is a comparison of Measures that focus on incentivizing:
- Development of Digital solutions to be sold to Customers
- Customers to invest in Digital solutions
- Development of Circular Solutions to be sold to Customers
- Customers to purchase Circular Solutions
- Servitized Technology to be sold to Customers
- A Servitization of the purchasing process

It is possible to argue that Digitalization enables but does not necessitate rapid development of CS. An approach with a focus on Digitalization Measures as a path to the CE may also be inefficient due to the "alarmingly" low success rate of digitalization projects [19].

One precondition for Measures that efficiently incentivize development of CS and purchasing of CS is attractive business cases and commonly accepted Circular business models. However, "There is still considerable lack of clarity about their [circular business models] theoretical conceptualization" [20]. Before this clarity has been achieved and clear business cases been identified, it can be assumed that implementation rate of commercial CS will be limited, as already have been observed [4].

Measures that incentivize Servitization of Technology and development of Value proposals to be offered to Customers, require a broad Customer base that has developed internal processes to identify and specify desired Value to purchase, and also is ready to shift focus from purchasing Technology and adopt business models where suppliers are instead remunerated for created Value, if this approach is going to result in a rapid introduction of the CE. This broad Customer base cannot be identified currently. Instead there are indications that only a limited share of companies may have developed internal processes for identification and specification of desired Value from Technology purchases [21].

However, based on the above and the reasoning in earlier chapters there are indications that one particular type of Measures could have the potential to tie all three concepts together, take advantage of 'all' different resource-efficiency enablers, and contribute to a rapid introduction of the CE: *Measures that incentivize purchasing departments to switch business model to only remunerate suppliers for created Value,*

and not for supplied Technology, and that stimulate the creation of a broad Customer base demanding Value proposals. Focus on this type of Measures could have many advantages for the CE introduction:

- Such Measures must by necessity include support for development of efficient methods to specify desired V/R fractions. As the "alarming" failure rate of digitalization projects often is caused by inadequate specification of desired V/R from digitalization projects, this approach could improve the general digitalization success rate.
- Such Measures would incentivize Servitization of Technology and take advantage of the Technology Servitization trend (obviously).
- It would incentivize Digitalization and the use of smart products. Payment for created Value requires methods to measure actually created Value, advanced communication solutions, and a host of other solutions for information handling. Smart products may be 'expensive' to buy using 'old' business models but can often be used as resource-efficient tools for low-cost Value creation over time. If Developers of smart products benefit economically from efficient utilization of their own smart products, a rapid adoption rate of smart products, and growth of companies that develop smart products, can be assumed.
- It would incentivize utilization of digital platforms. Efficient creation of Value will incentivize a systemic approach and efficient utilization of the whole network of Developers, Customers, Third Parties and Resources that can be mobilized for this objective. This will stimulate the development, as well as utilization of digital platforms.
- A CE approach focusing on such Measures have the benefit of being simple. It may e.g. be possible to require state-owned companies, universities, research institutes, and governmental bodies, to only use such business models, by decree. For example, these institutions could be required to only pay for 'good light' instead of 'lamps', 'indoor climate' instead of 'heating systems', 'transport experience' instead of 'vehicles', etc.
- It could also contribute to a definition of a circular business model as: *'Remunerating a supplier for created Value over a time-frame long enough to make it possible to reap the benefits from resources spent on development of Technology designed for resource-efficient VRP's.*

The above indicate that a CE approach focusing on Measures to incentivize increased demand for Value proposals could efficiently tie all three concepts together and incentivize further coordinated development. This is particularly true if complex Technology including IT is used as tools to create the desired Value, as this e.g. often will give Developers a significant competence advantage over Customers regarding the ability to resource-efficiently utilize and continuously improve the Technology that is used to create Value. It also indicates that this approach may contribute to the generation of a rapid, as well as resource-efficient introduction of the CE.

8. Discussion

There are several earlier works suggesting policies to facilitate the introduction of the CE, e.g. [22,8,23]. However, they all rather briefly mention the CE *incentivizing* power of rPSS, and focus primarily on highlighting policies that *practically* supports the development of CE enabling products, i.e. products designed for VRP's, saying e.g. that "A top priority for policy-makers must be the enabling of … consumption of VRP products." [8]. The analysis in this work, however, contribute to the CE research field by indicating that the top priority should be policies that stimulate and enable a change in business model, from payment of products, to remuneration for created Value. This incentivizes conceptual integration of Digitalization, Servitization, and CS, taking advantage of these concepts' combined resource-efficiency enablers, which in turn incentivizes the development of products designed for efficient VRP's.

This Value recipient perspective approach also contributes to the Servitization research field, as Servitization literature currently mainly takes a supplier perspective. The two Servitization literature reviews [24,25] for example, only briefly mention the recipient perspective. A more recent Servitization literature review covering the car industry [26] notice that "service researchers have made only limited efforts to identify the key customer requirements for an optimal carsharing experience", also supports the findings from earlier reviews, that researchers have had limited interest in carrying out demand side Servitization studies.

Finally, it suggests that the current Swedish National Circular strategy [27] could be complemented with Measures aimed at increasing demand for Value proposals.

9. Conclusions and future research

This study indicates that a CE strategy should focus on Measures that enable and incentivize Value purchasing, and stimulate the combined resource-efficiency enablers of the Servitization, Digitalization, and CS concepts. Several different Measures aimed at enabling Value purchasing could be taken, e.g. decreeing that governmental bodies and institutions should use Value purchasing business models, as well as supporting development of Value purchasing competence. It could be analyzed where the major obstacles for implementation Value-focused business models could be, e.g: Ability to identify and specify desired V/R to be maximized, measuring created V/R, identifying a suitable 'Circular' time-frame, or writing and using Value contracts.

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