# Living in a Pink Cloud or Fighting a Whack-a-Mole? On the Creation of Recurring Revenue Streams in the Embedded Systems Domain

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*Abstract*—For companies in the embedded systems domain, digitalization and digital technologies allow endless opportunities for new business models and continuous value delivery. While physical products still provide the core revenue, these are rapidly being complemented with offerings that allow for recurring revenue and that are based on software, data and artificial intelligence (AI). However, while new digital offerings allow for fundamentally new and recurring revenue streams and continuous value delivery to customers, the creation of these proves to be a challenging endeavour. In this paper, we study how companies explore ways to create new or additional value with the intention to complement their product portfolio with offerings that allow for recurring revenue. Based on multi-case study research, we identify the key challenges that companies in the embedded systems domain experience and we derive four organizational patterns that we see slow down innovation. Second, we present a framework outlining alternative types of offerings to customers. Third, we provide a value taxonomy in which we detail the different types of offerings and the value these provide to customers. For each value offering, we indicate whether this offering is *(1)* static or evolving, *(2)* bundled or unbundled, *(3)* free or monetized, and we provide examples from the case companies we studied.

*Index Terms*—digitalization, digital transformation, embedded systems, recurring revenue streams, customer value, innovation

## I. INTRODUCTION

Companies in the embedded systems domain are experiencing a rapid transformation of their businesses. Due to digitalization and digital technologies such as software, data and artificial intelligence (AI), these companies are looking to complement their physical products with software-driven offerings that generate additional or new value to customers and that allow for recurring revenue [1], [2], [3]. Across domains, we see a shift from a situation in which product generations constituted the primary way to deliver new value to customers towards a situation in which periodic software updates, continuous practices, feature experimentation and reinforcement learning methods allow for significantly shorter value creation and value delivery cycles. In a continuous value delivery model, the value that the product, system or offering provides is evolving and improving over time and the relationship to customers shifts from being a transactional and "one-off" relationship to a continuous relationship [2]. As recognized in our previous research [4], companies engage in different types of innovations to enable recurring revenue. They develop complementary services to their products, e.g., a company sells a car or a truck and offer services around it to improve product performance and/or customer experience. They experiment with ways to offer the existing product as a service, e.g., car-as-a-service or truck-as-a-service offerings. Finally, they explore cross-business ecosystem innovation opportunities where the company partners with customers, suppliers and others for new value creation.

However, although companies in the embedded systems domain are well-equipped for large-scale product and systems development, the innovation of new digital offerings proves challenging. Typically, and as explored further in this paper, this requires new skill-sets, cross-organizational ways-of-working and the adoption of a customer-driven innovation culture that goes beyond what is typically associated with agile ways-of-working and an agile mind-set.

In this paper, we study how companies explore ways to create new or additional value with the intention to complement their product portfolio with offerings that allow for recurring revenue. As the basis for our research, we present findings from on-going multi-case study research in which we engage with companies in the embedded systems domain.

The contribution of this paper is threefold. First, based on the challenges that we see the case companies experience in the creation of recurring revenue, we derive four organizational patterns. These patters reflect behaviors and cultures that exist in the case companies and that slow down innovation initiatives. Second, we present a framework outlining alternative types of offerings to customers. Third, we provide a value taxonomy in which we detail the different types of offerings we see and the value these provide to customers. For each value offering, we indicate whether this offering is (1) static or evolving, (2) bundled or unbundled, (3) free or monetized, and we provide examples from the case companies we studied.

The remainder of the paper is structured as follows. In section II, we review literature on digitalization and digital

transformation of the embedded systems domain. In section III, we present the research method and the case companies involved in our research. In section IV, we identify the key challenges that companies experience. In section V, we derive four organizational patterns that slow down innovation, we present a framework outlining alternative types of offerings and we provide a value taxonomy in which we detail the different types of offerings we see and the value these provide to customers. In section VI we discuss threats to validity and in section VII, we conclude the paper and outline future work.

## II. BACKGROUND

### A. Digital transformation of the embedded systems domain

During the last decade, companies across domains have experienced a rapid transformation of their conventional businesses. A primary driver for this transformation is digitalization and the digital technologies that have been introduced. As recognized in [5], digital transformation involves technological, organizational and social dimensions and to summarize the various definitions that exist, the authors define digital transformation as the use of new digital technologies to enable major business improvements.

For companies in the embedded systems domain, digitalization means the introduction of software, data and AI technologies to systems that have their origin in mechanics and electronics [6]. Although embedded systems such as telecommunications systems, vehicles, power plants, radar systems, and security cameras have included software components and generated data for decades, the increasing use of digital technologies we experience today is redefining businesses and disrupting entire value chains. As an example, the automotive industry is undergoing very rapid technological changes with e.g., automation and infotainment, advanced driver-assist systems (ADAS), autonomous drive. As noted in [7], high-end cars of today may contain 150 ECUs or more, and even low-end vehicles are quickly approaching 100 ECUs and 100 million of lines of code. In the telecommunications domain, drones make it possible to perform remote engineering and network planning tasks, automate tower inspections, and enhance the measurement of wireless coverage and performance [8]. In the manufacturing domain, AI components allow flexible and configurable factories that can autonomously reconfigure their product lines. The examples are endless and with each new technology being introduced, there are also new business model opportunities [2], [3], [9], [10], novel ways-of-working [4], and disruptive ecosystem forces [1] to strategically manage.

### B. Towards recurring revenue streams

To benefit from digital technologies, and to exploit the opportunities of software, data and AI, companies need business models that allow for recurring revenue. As recognized in [11], value creation includes activities for developing, manufacturing, and selling products, providing services, and integrating them into customer-specific solutions. With regards to profit, both products and services contribute to revenue but with services currently being the smaller slice when looking at manufacturing companies [11]. In our previous research [4], we see a similar pattern with recurring revenue being limited. To increase recurring revenue, companies need business models that support continuous delivery and capture of customer value. While examples of such models are common in the Software-as-a-Service (SaaS) domain [12], they are still gaining momentum in the embedded systems domain. Already today, we see examples of e.g., subscription models, license models, and pay-per-usage/access/performance models, but for many companies the pricing of value provided by digital technologies remains a challenge. For example, although data revealing product performance is collected, this is typically difficult to monetize since it has traditionally been part of the product package and therefore, something customers are used to get for free. To monetize, companies need to provide value that goes beyond existing sales and that provide customers with insights they didn't already have [13].

### C. Customer-driven innovation

The case companies in our study use agile development methods as the basis for product development [14], [15], [16], [17]. Moreover, continuous integration and continuous deployment practices [18] allow the companies to align development and operations of their products and the majority of the companies are adopting DevOps practices [19], [20] for continuous deployment of new functionality. However, exploring and effectively exploiting new value propositions to allow for a shift in sales and business models requires more than what is typically associated with agile ways-of-working. In addition to the adoption of cross-functional teams, sprints, and iterative development, innovation initiatives that aim to generate new and recurring revenue streams require a shift towards customer-driven innovation and lean start-up ways-of-working [21], [22], [23], [24]. In addition, companies need experimentation practices and mechanisms that help them continuously deploy, measure and evaluate what constitutes customer value [25], [26], [27], [28]. As recognized in [24], agile development methods help answer 'how' to build products and how to increase speed in development. However, they don't necessarily help in answering 'what' products to build and 'what' constitutes customer value. Similarly to a start-up context, neither the problem nor the solution is well understood with regards to innovation of new value propositions. Therefore, companies need methods, processes and tools that focus not only on the technical solution itself, but also on overall business strategies and needs, e.g. an associated business model, targeted marketing efforts, and the establishment of customer relationship models.

## III. RESEARCH METHOD

### A. Case study research

The research reported in this paper is part of a research initiative in which we conduct longitudinal multi-case study research [29], [30] in close collaboration with 17 companies in the embedded systems domain (for more information visit

www.software-center.se). The companies represent domains such as telecommunications, automotive, defense, security, healthcare, wind-power, marine solutions, transport and logistics, and they are all large-scale software-intensive companies. With their products becoming increasingly connected, and with digital technologies becoming critical for innovation of new customer value, these companies are currently exploring how to complement, improve and redefine their current businesses with value offerings that allow recurring revenue streams.

In this paper, we report on on-going research in which we explore the challenges that these companies face when exploring how to generate new or additional value with the intention to create recurring revenue streams. As the basis for our findings, we use company workshops, frequent check-in meetings and insights from cross-company workshops and events conducted between August 2021 and April 2022. For the purpose of this study, and in alignment with our research interests, we adopted a qualitative research approach. As reported in literature [29], case study research is especially suited for research concerned with identifying patterns of action and for studying organizational contexts in which emphasis is put on stakeholder's perceptions, experiences and understandings of a certain phenomenon and its associated challenges.

### B. Case companies

This paper reports on on-going research which we initiated in August 2021. Since then, we work closely with a selected set of the companies, i.e., primary case companies, while we continuously also learn from, and interact with, the larger set of companies. In our primary case companies, we engage closely with teams that are involved in, and responsible for, innovation and development of new value propositions. The primary case companies are briefly described below:

- *Case company A* is a company manufacturing trucks, buses and construction equipment as well as a supplier of marine systems. For the purpose of this paper, we engaged with a team responsible for new service innovation.
- *Case company B* is a solution provider for the material handling business. For the purpose of this paper, we engaged with the leadership team and with roles responsible for software strategy and innovation.
- *Case company C* is a company developing products, services and solutions for military defense and civil security. For the purpose of this paper, we engaged with product managers, senior project managers and roles responsible for sales and marketing.
- *Case company D* is a company providing product development, marketing, engineering, sales and support for crew planning and optimization of product lines. For the purpose of this paper, we engaged with a team involved in development of new service offerings and roles representing software, architecture and portfolio.

In addition to the four primary case companies, we use insights and experiences from the larger set of companies

as as the basis for our findings. These companies experience similar challenges with regards to innovation and new business models as the primary case companies and they are equally interested in growing recurring revenue. While we engaged with the primary case companies in company workshops and frequent check-in meetings, we met with the larger set of companies on a less frequent basis and primarily at cross-company workshops and events.

### C. Data collection and analysis

As the primary data source for this study, we engaged in workshop sessions at all primary case companies in which we met with key stakeholders in teams involved in, and responsible for, innovation and development of new value propositions. The workshop sessions lasted for 2–3 hours and involved 4–10 people. In addition to the workshops, we had bi-weekly and/or monthly check-in meetings to review status of the initiatives, current challenges and where we together discussed solution development and next steps. With the primary case companies, we engaged in two workshops/company between August - December 2021. In between these, we had short check-in meetings. Similarly, during January - April 2022, we organized two workshops/company and in between these we had shorter check-in meetings (except for case company C that we didn't meet with due to organizational changes). In total, the research we report on in this paper is based on 14 company workshops where we met with larger teams, 12 check-in meetings and a large number of email and follow-up discussions with teams and individuals in the four companies. Moreover, we engaged in two cross-company workshops to which the larger set of companies were invited, and two larger research events with all companies represented. For data analysis, we adopted an interpretive approach [29], [30], [31]. As suggested by [31] the generalizations that are made based on case study research are useful for other organizations that experience similar challenges in similar contexts.

## IV. FINDINGS

The case companies in our research all seek to complement and replace their existing transactional revenue with recurring revenue streams from new offerings as well as changed business models from existing offerings. This requires these companies to adopt a customer-driven innovation process that is quite different from the technology-driven innovation process that these companies are well versed in. The companies are experiencing several challenges that we outline in the remainder of this section.

***Difficulties in adopting a customer and use-case driven innovation approach:*** All case companies are successful in developing software-intensive systems and they are among the top players in the market and customer segments they serve. During workshop sessions, we noticed that the approach they take to development is typically a technology and partner-driven approach. This means that ideas and innovations are developed internally, or in collaboration with partners, but that these are primarily based on internal assumptions about

what customers need. For the case companies with an origin in mechanics and electronics, and with very deep technical expertise, this is the traditional way of working and an approach that, has proven very successful with regards to the physical products they develop. However, developing digital offerings based on software, data and AI, requires a different approach. For this, the respondents in our study recognize that they need to adopt a more customer and use case-driven innovation approach. In company A, this is explained by one of the workshop participants when saying: *"We fail in identifying the real pain-points of our customers and this leads to a situation where we base ideas for new services on assumptions and experiences rather than on validated customer problems."* In this company, people agreed that the challenge is not so much to generate novel ideas but rather to prioritize and validate these ideas with customers. During our study, the majority of the respondents shared that for customer-driven innovation to be successful, you need access to customers for rapid and continuous validation of ideas, you need a mind-set that advocates MVP development rather than completed functions and you need to measure and learn from customers before (and during) development in ways that are not the typical within large-scale embedded systems companies.

*Insufficient methods and processes for new value creation:* With product development being the core business, the case companies report on systematic methods and processes in place for what is often referred to as Horizon 1 innovations, i.e., continuous innovation to existing business models and core capabilities [32]. For Horizon 1 innovations, the case companies optimize what they already have in place by doing small improvements of the existing products or by improving their internal processes. However, to develop new offerings requires new methods and processes. It falls within what is referred to as Horizon 3 innovation, i.e., non-incremental innovations of a disruptive and radical nature and where one successful innovation typically generate more revenue than all other initiatives combined. During our study, we learnt that skills for Horizon 3 innovation are missing. The teams we met with use 'Design Thinking' and 'Lean Start-up' methods as guidance but finds it difficult to apply and tailor these to support the specific needs of the business-to-business (B2B) industry domain. One of the team members reflects on this when saying: *"Service design people across the organization tend to work from the assumption that "if the customer has said it, it is true"* rather than actively evaluating their assumptions with customers".

*Challenges in moving towards "cross-organizational teams":* The case companies use agile methods and cross-functional teams and appreciate the many benefits of short sprints, iterative development and DevOps practices for aligning software development with operations. However, the traditional agile approach and the typical cross-functional team set-up with teams consisting of development, testing, and operations, is not enough when it comes to innovation of entirely new customer value. For such value creation, cross-functional teams need to include also marketing, sales etc.,

and sometimes even different company branches. In company A, the service innovation team involve people who belong to different organizations and who report to different line managers. As much as this is considered key for success it also proves challenging in practice. Similar experiences are reported in the other companies where the notion of "being one team and working towards the same goal and backlog" is a constant battle.

*Inability to prioritize, evaluate and go beyond the existing:* Throughout our study, the case companies experienced challenges related to the ways in which innovation of new offerings are conducted. Typically, top management asks for new value and new offerings with the desire to increase recurring revenue. According to representatives from the case companies, this often leads to a situation in which innovation initiatives are initiated by "everyone everywhere" but without a strategy for how to prioritize and evaluate these with customers. As recognized by one of the innovation team members in company A, this leads to a situation in which the majority of efforts are spent on Horizon 1 ideas, i.e., adding services to existing products, and only very little effort is spent on Horizon 3 ideas, i.e., creating new revenue streams. As a consequence, revenue might increase slightly, but value that goes beyond the existing product is not generated and no new and recurring revenue streams are created.

*Lack of product capabilities for digital innovation:* To add value to products by using new digital technologies is something that all case companies are eager to do. All companies have ideas in the pipeline and the majority of the people we engaged with during our study feel the company is moving in the right direction. However, a common challenge is that often the existing product, i.e., the physical offering, lacks the capabilities needed for new innovations. As an example, company A is exploring services that requires the trucks to be connected as well as being able to identify and communicate with surrounding devices. While some of the products, in this case trucks, have these capabilities, others lack these capabilities. Similarly, physical products in the other case companies often lack capabilities needed for new innovations. As a result, innovation initiatives suffer since if the product capabilities are missing the service will be difficult, or impossible, to realize.

*Lack of payment infrastructures:* As a major challenge, the case companies refer to the difficulties involved in validating whether customers are willing to pay for the value that new offerings provide. All companies use agile ways-of-working, and they develop Minimal Viable Products (MVPs) as part of their sprints. Still, to continuously validate these with customers is difficult. And even if getting access to customers, validating the MVP is one thing but validating the willingness to pay is another. According to one of the case companies, this limits the opportunities to establish a business case as the value of a new offering is difficult to "prove" internally as long as there is no numbers backing this up.

## V. DISCUSSION

Although previous research emphasizes the many ways in which digitalization and digital transformation allow for new business models, new value propositions and fundamentally new ways-of-working with regards to customer relationships [2], [4], [9], there are few studies that show how these opportunities are explored in practice and how companies in the embedded systems domain are able to exploit new value propositions.

In this section, we discuss our empirical findings and we conceptualize the insights we got from the case companies. First, based on the challenges we identified, we derive four organizational patterns. These patters reflect common behaviors and cultures that exist in the case companies and that slow down innovation initiatives. Second, we present a framework outlining alternative types of offerings to customers. Third, we provide a value taxonomy in which we detail the different types of offerings we see and the value these provide to customers. For each value offering, we indicate whether this offering is (1) static or evolving, (2) bundled or unbundled, (3) free or monetized, and we provide examples from the case companies we studied. The four organizational patterns, the framework and the taxonomy are generalizations that we derive from the empirical data we collected. Together, they capture our understanding of the challenges companies experience and the approaches companies take to create recurring revenue streams by innovating their existing product portfolio.

### A. Organizational patterns

*Gold-plating pattern:* The gold-plating pattern refers to the desire of engineering organizations to develop the complete functionality and ideally, complete systems, before validating these with customers. Despite the aim and attempt to develop smaller slices of functionality, the case companies confirm that these tend to be much more complete than what is expected from an MVP. In one of the case companies, one of the product managers described the situation as: *"We want to create the 'perfect offering' before testing and evaluating it with customers"*. Organizations where the gold-plating pattern is prevalent run the risk of wasting resources on functionality that, in the end, proves to add little customer value.

*Pink Cloud pattern:* The pink cloud pattern refers to the danger of letting assumptions and existing experience guide development. The case companies in our study confirm that although they typically don't have direct access to customers, the organization easily uses this as an excuse for not exploring novel ways-of-working and proactively engage with selected and friendly customers. One of the digitalization managers in one of the case company shared his view of this when saying: *"We work agile, and we say we use a DevOps approach – but do we engage with the customer...!? Not really..."*. Organizations where the pink cloud pattern is prevalent run the risk of having outdated assumptions remain the basis for development and hence, miss out on novel customer needs.

*OPAB pattern:* The OPAB pattern refers to the difficulties of allocating resources for innovation initiatives. In the case companies, traditional company structures and hierarchies make people organize around functions, products and solutions which makes everything outside the "typical" difficult. In addition, the traditional structures bring a "silo mind-set" that is difficult to shift around even if organizations know they need novel ways-of-working with regards to innovation. Organizations where the OPAB pattern is prevalent let the existing organization (O) and the already well-established processes (P) guide architecture (A) and business (B) instead of the opposite way around. The risk these organizations run is to have the existing structures hinder, and even disable, innovation and future business opportunities.

*Whack-A-Mole pattern:* The whack-a-mole pattern refers to the constant battle of aligning, and having people prioritize, a new initiative. In the case companies, innovation initiatives involve multiple functions e.g., development, operations, marketing, business that need to come together. Often, however, there are functions that are unable to prioritize the initiative and that cause problems that bring the initiative into a deadlock situation. When the "blocking functions" finally come around and prioritize the initiative, there is someone/something else that pops up and blocks the progress. Organizations where the whack-a-mole pattern is prevalent experience very slow progress and run the risk of being too late compared to competitors.

### B. Value Offerings Framework

As reported in the empirical findings section, the case companies are product companies with the core revenue being product sales. Already today they have service sales and service revenue streams, but these are limited and a common characteristic for the case companies is that they look to grow their recurring revenue streams. To do this, the case companies explore different types of value offerings that complement, extend and add to their existing products. In Figure 1, we present a framework outlining alternative types of offerings that we see the case companies provide customers.

As the first and most common offering, companies develop *product-oriented value* to customers. This type of offering focuses on e.g., product performance, product health and preventive maintenance. Typically, the products that the case companies sell to customers are premium priced and product-oriented value come as part of the product package. This means that although these offerings add value they offer few opportunities for revenue, and no revenue streams that go beyond the existing sales since customers are used to get this value "for free" as part of the product. From this perspective, and as pictured in Figure 1, product-oriented value is considered "commodity" as it adds to the existing offering rather than provide new value to customers.

As a second type of offering, companies shift focus from the product towards the customer and start developing *outcome-oriented value*. These offerings provide individual customers with insights that help the customer monitor his/her own productivity, efficiency and/or quality, services that support life cycle management and services that support device and asset
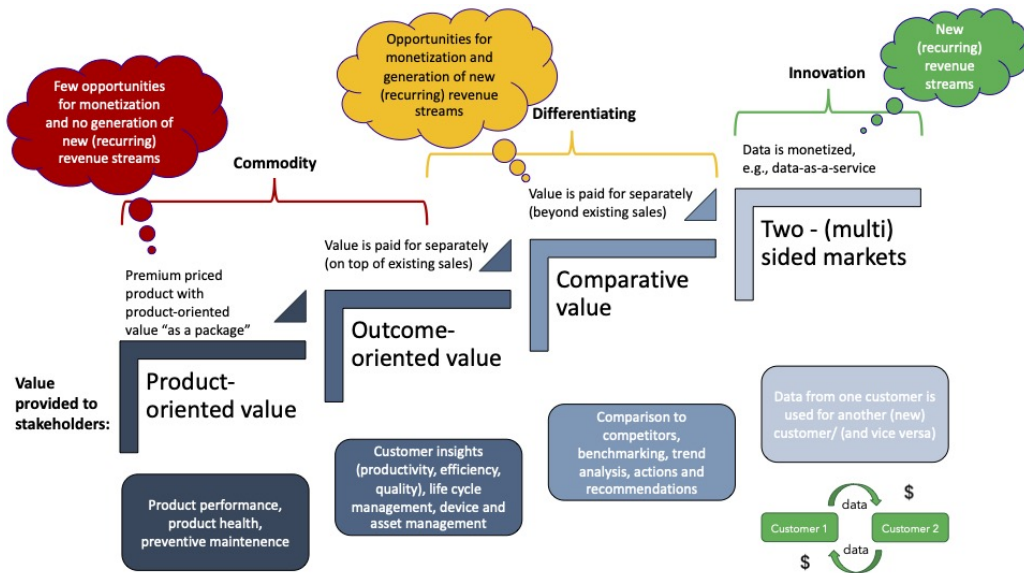
Fig. 1. Value Offerings Framework: Alternative types of offerings that we see the case companies provide customers.

management. In the case companies we studied, outcome-oriented value can be included in the product and "free", or paid for separately and on top of existing sales. From this perspective, outcome-oriented value enables companies to transition towards more differentiating offerings that add new value to customers and that generate recurring revenue to the company.

Third, *comparative value offerings* allow customers to not only monitor and gain insights in their own performance, but to also compare and benchmark to others. As an example, case company A offer truck drivers the opportunity to compare their performance to other truck drivers within a fleet. Similarly, fleet owners can compare themselves to other fleet owners. Other examples of comparative value offerings are benchmarking opportunities, trend analysis, actions and recommendations. While the two previous types of value offerings are primarily part of the product package, comparative value offerings are paid for separately and go beyond existing sales. Also, they provide customers with new value. From this perspective, comparative value offerings help companies differentiate and they enable entirely new revenue streams to the company.

Finally, and as a fourth type of offering, companies start monetizing data collected from its existing customer base with new customer segments. This is referred to as *two- and multi-sided markets* and provide companies with a wide range of new opportunities. As an example, you could imagine data collected by vehicles that reflect e.g., road conditions, to be valuable for road authorities and/or other stakeholders. Similarly, data collected from mobile networks might prove valuable for a number of stakeholders outside the telecommunications domain. While two and multi-sided markets is a well-established model in the online domain, and to some extent also in other domains, [33], [34], [35], it is not yet a business model that the embedded systems companies involved

in our study actively exploit. However, there is the potential and several of the industry representatives refer to this type of value offering as something they want in the future. As can be seen in Figure 1, it is an innovative type of offering that brings value for existing as well as new customers as data is shared and monetized in both directions.

### C. Value Taxonomy

Based on the workshop discussions in the case companies, we learnt that although everyone seeks to add new value and complement existing products with new value offerings, this is achieved in many different ways. Also, we note that each type of offering, i.e., product-oriented, outcome-oriented, comparative, and two- and multi-sided markets, provide customers with a number of more or less advanced offerings ranging from pure visualization of data to advanced and automated actions. In Figure 2, we provide a taxonomy in which we detail the different types of offerings and the value they provide. For each type of offering, we indicate whether this offering is (1) static or evolving, (2) bundled or unbundled, (3) free or monetized, and we provide examples from the case companies we studied. In the taxonomy, we use the following notations to indicate what types of offerings we observed in the case companies involved in our study:

- *Green:* Examples we observe in one/multiple case companies
- *Orange:* Examples we heard about and that one/multiple case companies want/explore/plan for
- *Red:* Examples that were discussed but not yet explored and/or planned for

As can be seen in the taxonomy, all case companies are actively exploring offerings that provide customers with product and outcome-oriented value. Also, offerings allowing for comparisons to others are common. For all types of offerings,

| Value provided to stakeholders: | Visualization | Opinionated insights | Recommended actions | Automated actions |
|---|---|---|---|---|
| Product-oriented value | Example: Product health dashboard<br>Static<br>Bundled<br>Free | Example: Preventive maintenance<br>Static<br>Bundled<br>Free | Example: Predictive maintenance<br>Evolving<br>Unbundled<br>Monetized | Example: Automated maintenance service ordering<br>Evolving<br>Unbundled<br>Monetized |
| Outcome-oriented value | Example: Milk packages/hour<br>Static<br>Bundled<br>Free | Example: Underperforming network nodes<br>Static<br>Bundled<br>Free | Example: Gear shift recommendation<br>Evolving<br>Unbundled<br>Monetized | Example: Adjust engine power output<br>Evolving<br>Unbundled<br>Monetized |
| Comparative value | Example: Aggregated industry performance data<br>Static<br>Unbundled<br>Monetized | Example: Industry trend analysis<br>Evolving<br>Unbundled<br>Monetized | Example: Truck allocation to improve AVG load %<br>Evolving<br>Unbundled<br>Monetized | Example: Dynamic pricing<br>Evolving<br>Unbundled<br>Monetized |
| Two- (multi) sided markets | Example: Logistics time series data<br>Static<br>Unbundled<br>Monetized | Example: Regional passenger traffic deviations<br>Evolving<br>Unbundled<br>Monetized | Example: Road salt allocation recommendations<br>Evolving<br>Unbundled<br>Monetized | Example: Hedge fund trading based on logistics data<br>Evolving<br>Unbundled<br>Monetized |

Fig. 2. Value Taxonomy: For each type of value offering, the taxonomy indicates whether the offering is (1) static or evolving, (2) bundled or unbundled, (3) free or monetized, and what it provides customers in terms of visualization, opinionated insights, recommended actions or automated actions.

the companies explore opportunities to provide customers with visualization, with opinionated insights, with recommended actions and/or automated actions. Typically, selling "raw" data is not the preferred model. Rather, selling aggregated data, analysis, insights and offerings supporting decision-making brings value that customers are willing to pay for. What is not yet well-established in the case companies are offerings that autonomously conduct actions on behalf of customers. Although this is regarded as highly valuable, our empirical data only shows a few examples. In the automotive domain, there are examples such as automated adjustment of engine power output based on location and we also see companies exploring automated ordering of maintenance. Also, outside the case companies and the embedded systems domain, we see companies that are successfully exploiting dynamic pricing as well as services for two- or multi-sided markets. The two- and multi-sided market model is discussed and recognized as important in the embedded systems industry, but there are very few examples emerging.

Although this is still on-going research, we recognize four patterns that we believe are significant and worth mentioning. First, the case companies typically explore three types of innovation, i.e. complementary offerings around the product portfolio, changing the business model for the product portfolio itself from transactional to recurring and, finally, cross-ecosystem innovation where the company partners with customers, suppliers and others for new value creation.

Second, our findings indicate that the focus for any new value offering should be far enough from the core business of a company so that internal stakeholders don't feel challenged and so that customers recognize the offering as new and worth paying for. However, it has to be close enough so that the company uses its unique capabilities and has an "unfair advantage" due to its domain knowledge.

Third, we see that companies that are successful in innovation are those that identify ways to introduce recurring business models aligned with the customer KPIs, e.g. paying for movement, performance or productivity improvement. In such models, the product becomes an enabler for complementary and new value offerings rather than the main focus.

Fourth, for successful innovation of new value offerings, companies need to shift from technology-driven to customer-driven innovation. This requires a deep understanding of the customer to identify customer needs that either are currently not met or that are likely to instantiate in the future due to strategic trends. The customer-driven innovation approach goes beyond what is typically associated with the agile ways-of-working and the agile mind-set that the case companies so far adopted.

## VI. THREATS TO VALIDITY

As the foundation for our understanding of digitalization and digital transformation, we reviewed contemporary research on this topic. Based on this understanding, we conducted multi-case study research in collaboration with companies in the embedded systems domain. As our primary data source, we collected data from workshops with key stakeholders within each of the case companies. To address construct validity [30], we shared our understanding of digital transformation, and the impact this has on innovation, in the opening of each workshop. In this way, our workshop discussions were based on terminology that was familiar for everyone. With regards to external validity, we view our research contributions as related to the "drawing of specific implications" and as a contribution of "rich insights" [31]. However, with the opportunity to study companies covering different industry domains we believe that the findings, and the conceptualizations of these, have the potential to be relevant also in other embedded systems companies with similar characteristics as the companies we studied.

## VII. CONCLUSIONS AND FUTURE WORK

The essence of digitalization is the fundamental shift in value delivery to customers, moving from transactional revenue to recurring revenue streams. In this paper, we studied

how companies explore ways to generate new or additional value with the intention to complement their product portfolio with offerings that allow for recurring revenue.

The contribution of the paper is threefold. First, we identify the key challenges that companies in the embedded systems domain experience and we derive four typical organizational patterns that we see slow down innovation. Second, we present a framework outlining alternative types of offerings to customers. Third, we provide a value taxonomy in which we detail the different types of offerings we see and the value these provide to customers.

In future work, we aim to study offerings for two- and multi-sided markets as this area presents the primary unexploited opportunity for the case companies. In addition, we aim to study the transition from providing visualization and insights to recommending or even autonomously performing actions on behalf of customers.

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