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How Digital Transformation affects Enterprise Architecture Management – a case study

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Abstract:
Internet of Things (IoT), machine learning, cyber-physical systems and other recent technological innovations offer new opportunities for enterprises in the context of Digital Transformation (DT) but also cause new challenges for Enterprise Architecture Management (EAM), which traditionally deals with enterprise-IT planning and coordination. Based on an industrial case of a power garden products manufacturer that is exploring potentials and facing challenges in DT, this article investigates the integration of product-IT into EAM. Product-IT includes the embedded IT-systems in physical products and services, components for operations, maintenance or evaluation purposes. In this article we discuss product-IT and enterprise-IT integration in the context of EAM observed in the industrial practice. The main contributions are (1) positioning of the product-IT in the field of EAM, and (2) identification of the challenges from real-world case regarding integration of product-IT into EAM.

Keywords:
product-IT; smart, connected product; digital transformation; enterprise-IT; enterprise architecture management; digitalization.

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1. Introduction

Today's dynamic business environment with its rapidly advancing information technology (IT) capabilities evolving phenomena such as Internet of things (IoT), cyber physical systems (CPS), machine learning or self-organizing systems, presents enterprises with both new opportunities and new challenges. This opens up for new ways for enterprises to organize themselves in terms of business models, practices, and processes, how they communicate with their customers, deliver services, perform product development etc., which is often discussed in relation to digital transformation (DT) [1] and digitalization [2] of enterprises. In general, digital transformation describes the shift from traditional (often physical) creation and delivery of customer value, including the operational procedures related to this, into the massive use of digital technologies which enhance or replace the traditional product with smart, connected product [1]. At the same time as enterprises see new opportunities they do face several challenges.

The various aspects of an enterprise possibly affected by digital transformation include organizational structure, business processes, information systems, and infrastructure, which together form an Enterprise Architecture (EA). The management of EA is a discipline that seeks to address mutual alignment between these aspects by taking the embracing perspective on the overall EA [3]. When it comes to models representing these aspects, the quality and completeness of information often decreases when going from top to bottom [4]. The top layers of architecture models usually contain more complete and up-to-date information. For lower levels information about concrete IT services and applications is often difficult to collect and keep up-to-date. All IT solutions and application that are used at the enterprise to support its functioning and operation is what we refer to as ***enterprise-IT*** (E-IT). This part is sometimes addressed as Enterprise Information Systems (EIS) and can include various ERP components [5]. In addition, introduction of smart, connected products increase the amount of data on lower levels, which is technologically enabled by CPS and IoT. Within CPS and IoT, data is produced by numerous communicating entities. These entities are usually IT-components built into the products, which we refer to as ***product-IT*** (P-IT). In particular, enterprises in manufacturing industry, and in sectors where a lot of value creation is represented by IT-components built into the products, find a lot of new opportunities created by seamless and real-time integration of physical systems and IT. Use of real-time data for enterprise architecture analytics has been a challenge due to shortcomings of IT possibilities (limits in volume, variety and speed of data collection), and by the fact that P-IT has mostly been considered separately from EA. Advancement in the area of Big Data helped to overcome the first challenge [4], whereas overcoming the second challenge still requires finding a way to deal with E-IT and P-IT in an integrated manner, from managerial and operational perspective. Even though the areas of EA, and variants of P-IT attracted a lot of research during the last 10 years not much work has been done on their integration, i.e. positioning P-IT into EAM consideration. Similar deficiencies can also be found in the area of enterprise modeling techniques that are used to represent various aspects of EA and support EA Management (EAM) [6, 7].

In this context, it is observable that in industrial practice, digital transformation can have different shapes and cause diverse types of challenges. There are for instance many examples of new start-ups who have managed to embrace the digitalization wave. On the other hand, there is also evidence that more traditional enterprises with established and legacy IT-architectures have a much harder time to embrace and to take advantage of digitalization and move their business forward into this era [6, 8]. More knowledge is needed on what methods and approaches can reliably support DT in industrial practice.

The main purpose of our work is to present experiences from integration of P-IT and E-IT as an expansion of current EAM. Our main research question is: *How can product-IT and enterprise-IT be integrated in the context of enterprise architecture management?*

In this ongoing research work, the main findings presented in this article are (1) positioning of P-IT in the field of EAM, and (2) identification of challenges from real-world cases regarding integration of P-IT into EA. The rest of the article is structured in the following way: Section 2 presents related work and Section 3 the research method. In Section 4 an industrial case study provides empirical evidence of the current challenges. In Section 5 we discuss the case study from the perspective of our research questions and digital business models. The article ends with conclusions and ideas for future research in Section 6.

2. Related research

The background for our work is primarily related to EAM which is summarized in section 2.1. Furthermore, this section discusses possible implications for the EAM caused by P-IT integration in enterprise architectures in section 2.2.

2.1 EAM of today (AS-IS)

In general, an EAM captures and structures all relevant components for describing an enterprise, including the processes used for development of the EA as such [9]. Research activities in EAM are manifold. The literature analysis included in [10] shows that elements of EAM [11], process and principles [12], and implementation drivers and strategies [13] are among the frequently researched subjects. Furthermore there is work on architecture analysis [14], decision making based on architectures [15] and IT governance [16]. However, there is no specific focus on the integration of P-IT and EAM. Of specific relevance for P-IT integration are EAM frameworks identifying recurring structures in EA. In this context, TOGAF [17] is considered by many researchers as industry standard and defines three different architectural levels which are visible in many other frameworks: *The Business Architecture* defines the business strategy, governance, organization and key business processes. *The Information Architecture* often is divided into two sub-layers: Data Architecture and Application Architecture. The Data Architecture describes the structure of an organization's logical and physical data assets and data management resources. The Application Architecture provides a blueprint for the individual application systems to be deployed, for their interactions and their relationships to the core business processes of an organization. *The Technology Architecture* describes the physical realization of an architectural solution. The logical software and hardware capabilities, which are required to support the deployment of business, data, and application services, are also defined in this dimension [17]. In addition to EAM frameworks there are also different modeling languages to support different EAM activities. One such language is ArchiMate which is widely used for these purposes. The shortcomings of ArchiMate and its ability to address dimensions needed for digitalization has also been pointed out [7]. In their study they show how existing enterprise modeling approaches does not really work for modeling digital enterprise ecosystems. In the effort of modeling enterprise ecosystems they argue: *"The described example elaborates that we have to improvise for modeling such a simple scenario using ArchiMate*" [7].

2.2 EAM of tomorrow (TO-BE)

Ahlemann et al. [9] define EAM as a management practice that establishes, maintains and uses a coherent set of guidelines, architecture principles and governance styles to achieve enterprise's vision and strategy. Facing opportunities and challenges derived from the digital revolution, business leaders need new ways to conduct effective strategic decisions related to the increased digital enterprise [18]. With the huge diversity of IoT technologies and products enterprises have to leverage and extend previous EA efforts to enable business value by integrating the concept of digital into their business environment [19].

The impact of digitalization on enterprise systems in modern manufacturing is discussed in [20], which claims that IoT can support information systems of next-generation manufacturing enterprises effectively. Data acquisition systems are suitable to be applied in collecting and sharing data among manufacturing resources. However, they argue that the application of IoT in enterprise systems are at its infant stage, more research is required in modularized and semantic integration, standardization, and the development of enabling technologies for safe, reliable, and effective communication and decision-making. On the way towards IoT-inclusive EAM, [19] and [21] consider integrating the growing IoT architectural descriptions into a consistent enterprise architecture as a significant challenge.

In [21] an approach for the IoT application development is proposed, which includes a role-specific development methodology, and a development framework for the IoT. Architecture evolution approach proposed in [22] relies on the idea of integrating small EA descriptions (for each relevant IoT object) into a coherent EA description. EA-IoT-Mini-Descriptions include partial EA-IoT-Data, partial EA-IoT-Models, and partial EA-IoT-Metamodels that are associated with main IoT objects defined by the approach. Another initiative that tries to overcome these challenges is the lightweight EAM framework for digital transformation by [23]. This framework has its origin in TOGAF 9.1 with a focused customization.

One challenge that is apparent today in the digital transformation is the to handle the bimodal dimensions of the IT lifecycle [24]. The E-IT dimension (Mode1), designed for stability, efficiency, and low cost, which is closely related to traditional EAM. P-IT on the other hand (Mode 2) is constituted by development projects that help to innovate or differentiate the business. This requires a high degree of business involvement, fast turnaround, and frequent update, the so-called rapid path to transform business ideas into applications. In the literature this is acknowledged through that there is a need to handle “A two speed architecture for the digital enterprise” [8]. For digitally native enterprises and startups such as for example Netflix this is not a problem [8], since they have had the benefit of starting with a “clean slate” and think “digital” and take the advantage of this from the beginning without considering any legacy. This does however not work for more established enterprises. They have many years of delivered technology, architectures, governance, decisions structures, etc. The objective of the two-speed architecture is to differentiate the systems, architectures, and structures that must be flexible and agile (P-IT) from those that have to be more reliable and deliver the highest quality (E-IT) [8]. This approach will have to cut through the different layers of the technology stack and is as much about organizational architecture and process architecture as it is about technology architecture. Some researchers have proposed an architecture aiming at information system agility and scalability, for example [25]. In addition to this [1] have suggested to handle modern digital informed infrastructure through a new technology stack. In this structure they suggest an integration of P-IT and E-IT through three interrelated layers that include Product Cloud, Connectivity, and Product. We find this approach promising but we argue for that there still is a need for further elaboration of integration of P-IT and E-IT. Even if we have a two-speed architecture these two requires elaborated and systematized interconnectivity and they should have the ability to deliver a collaborative support for different business- and customer activities.

The increased adoption of digitalization through IoT, data analytics (big data), and cloud computing has opened new ways of thinking in many dimensions; customer involvement, optimized processes, and business models. In terms of business models [26] has presented a new business model that can be more suitable for organizing business in an IoT age. This and other new business models emerging in the digitalization age will have impact on the EAM practice. Furthermore, our observation is that there is neither a common understanding of the scope and content of the main activities in EA management and IoT or P-IT integration, nor has a commonly accepted reference method been developed [27]. EAM currently concentrates on E-IT side including number of its layers, whereas P-IT, i.e. what is built into the products or supporting industrial automation, is mostly outside of EAM consideration.

3. Research method

From a method perspective, the work followed the case study research approach. In addition to the case study we reviewed existing publications using *digital product* and *enterprise architecture* as a search terms. There are several relevant studies available published between 2014 and 2017, which are described above in the Related Research section. During the analysis of existing literature, we observed that there is not much work on the integration of P-IT into EA, however we could clearly see that the interest in this integration is growing. Thus, our investigation of an industrial case in this subject area aimed to better understand the challenges, hinders and potential integration paths.

Qualitative case study is an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the subject under consideration is not explored from only one perspective, but rather from a variety of perspectives which allows for multiple facets of the phenomenon to be revealed and understood. Yin differentiates various kinds of case studies [28]: explanatory, exploratory and descriptive. The case study can be classified as exploratory. We explore the phenomenon of P-IT in its natural organizational context. As focus of the case study, we decided to address the P-IT/EA integration from an architectural and a management perspective. The architectural perspective addresses commonalities in structure and components of P-IT and enterprise architecture. The management perspective concerns procedures for architecture development, implementation and maintenance. The aim of the case study was to see how the existing EAM practice was affected and challenged by implementing new type of products – physical products with built-in software. More concrete, the case study explores the following research questions:

Does the architecture of product-IT in the case study show similar levels as known from traditional EA?

If it is possible to either discover such levels or to assign existing components to these levels, an integration could be discussed using established EA layer thinking. If not, more substantial changes to enterprise architectures would be required to facilitate an integration.

Are there existing or potential commonalities between product-IT architectures and EA?

Existing commonalities could be existing services developed for both parts or processes running "across" both architectures. Potential commonalities are functionally similar or equivalent services or structures.

What are the central roles in product-IT management and are these roles comparable to the roles in EAM?

P-IT management is in this context supposed to include product management, architecture definition and integration into the overall architecture.

What are the cooperation processes between EA and product-IT architecture management?

If cooperation is established and common practice, how do the processes look like, and do they cover all architecture levels?

In the case study, we analyzed documents of the case study company, performed interviews, and modeling activities to describe the current AS-IS situation. The analyzed documents provided information regarding the existing architectural and managerial practices related to digital products and services at Husqvarna. Eight interviews were performed as part of the case study, all having semi-structured character. Semi-structured interviews enabled in-depth investigation the focus area and allowed capturing the respondents' perspective on a situation and event under study [29]. Semi-structured interviews imply using a predefined list of questions but allows the interviewer to follow up on leads provided by participants for each question (ibid). The interviews were carried out at Husqvarna Group AB, one of the respondents takes a top management position in of architecture and digital solutions at Husqvarna, whereas the other respondents were project managers, product owner, enterprise architects, and squad leaders. The chosen respondents were key stakeholders within a project of developing a new digital product at Husqvarna, part of them were representing P-IT side, whereas another part - E-IT side. The interviewer followed prepared interview guide connected to the four research questions outlined above. The questions in the interview guide aimed to explore the challenges that the respondents have faced and observed in relation to EAM practice and digitalization demands/opportunities, as for instance, increasing number of P-IT entities that companies need to deal with, the considerable influence these P-IT entities have on the amount of data produced, ability to manage and analyze the produced data, and the ability to manage it in an integrated way with an E-IT.

During the modeling activities we together with the different roles at Husqvarna have created descriptions (interaction models) of how these roles (project managers, product owner, enterprise architects, technical architects, and squad leaders) interact with each other, what the interactions objects are, and the interaction logic. This way of working with models have elucidated several challenges in their work with taking a substantial step into the digitalization age. An example of such an interaction model can be seen in the Figure 1.

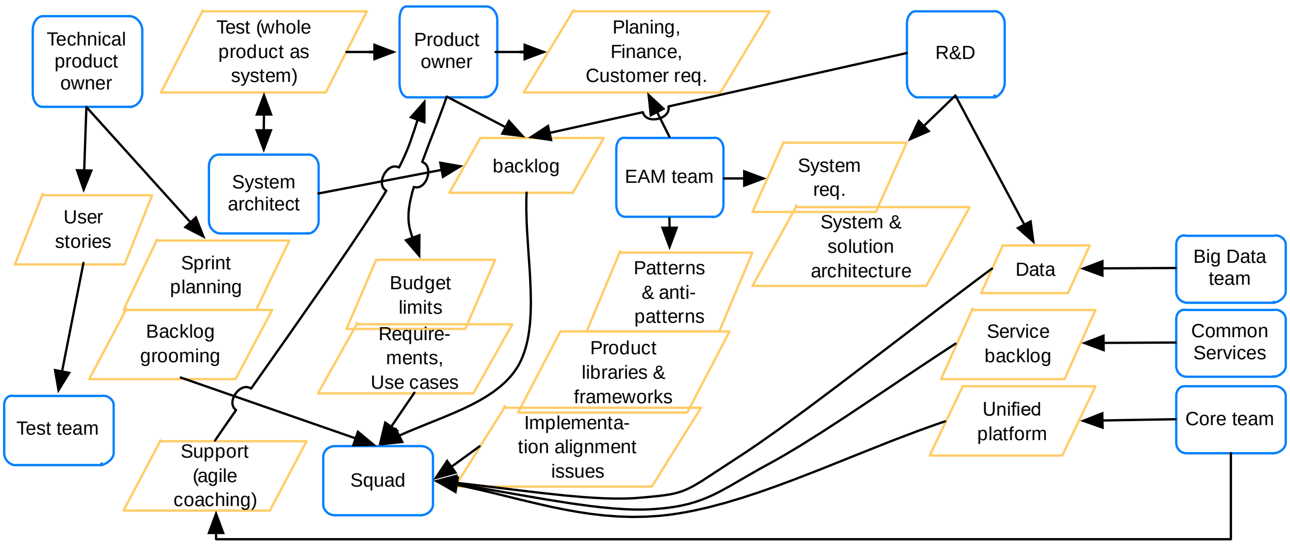

Figure 1: Overall interaction model

4. Industrial case study

The industrial enterprises considered in the case study is Husqvarna Group AB. Husqvarna is a world-leading producer of outdoor power products including chainsaws, trimmers, robotic lawn mowers, garden tractors, watering systems, cutting equipment, and diamond tools for the construction and stone industries. Husqvarna is multinational and offers products and services for both the private and industrial market. Husqvarna is right now in a transformation process where they see it as a necessity to embrace the digitalization trends that is been presented above to stay competitive and to deliver improved value to their stakeholders.

Many of the Husqvarna products for professional customers do not only have built-in electronics or embedded systems but also networking and communication capabilities. The built-in IT is in many cases used for controlling the different mechatronic components of the product and for collecting data when the product is in use, either performance parameters or used product features, or the environment of the product. The networking features are used for communicating usage statistics, license information or location information (if anti-theft features are activated) to either the product owner or the back-office of the manufacturer. Other functions are software upgrades and functionality add-ons implemented by configuration changes (e.g. for optimizing energy consumption).

Figure 2 illustrates a typical scenario from a customer perspective. Different Husqvarna products are installed for supporting maintenance of the garden, all of them equipped with wireless communication. Among them is a fleet of robotic mowers (1) and a lawn watering system (5). The robotic mowers and the watering system communicate with each other to synchronize mowing and watering, but they also provide operations data to the base station (2) and receive software updates or schedules from it. The base station is connected to the cloud by using the customer's Internet access. In the cloud, Husqvarna backend and customer services are available (3). Thus, the owner of the garden has access to services for operating, supervising and planning garden maintenance using mobile devices (4).

Since many of the products offer similar functionality regarding networking and communication, Husqvarna designed and implemented reusable services and components for either the product or the back-office infrastructure which comprise an IT and service architecture for the P-IT. To support all P-IT development teams Husqvarna introduced a team that is responsible for tools and standards for software development. This team is providing so called common development platform for all P-IT development teams.

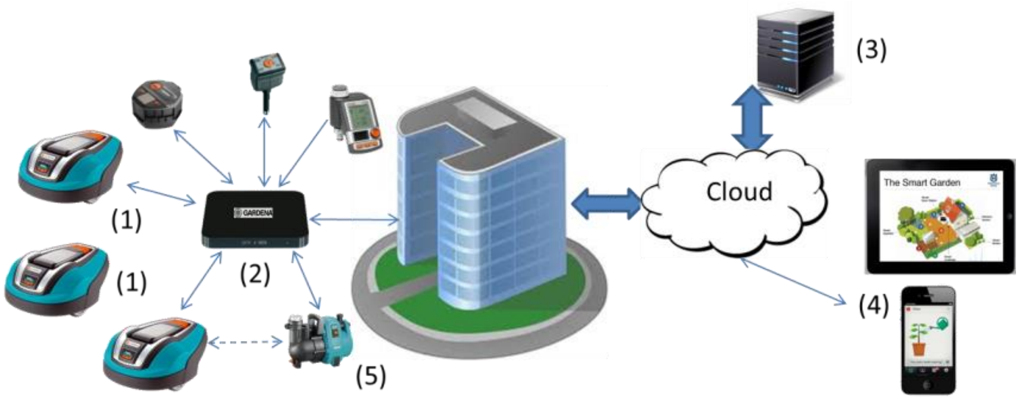

Figure 2: Scenario illustration

"Me and my team we are responsible for the common parts that all the teams are using for the development. For example, task management tools like JIRA and Confluence, build server, address verification system, source code management. We are also managing cloud infrastructure. All the teams are responsible for their own environments, but if they for some reason fail or need support they come to me and my team for help. We also try to outline common patterns, so they don't have to reinvent the wheel all over again, a lot of the things they want to do are common among all the teams." (Respondent 2)

One example of a common development platform component is a task management system JIRA. The decision to make this ticket management system "standard" originated from different product teams and their shared choice. This helped to avoid using several instances of JIRA and prevent situations when one person had to work in multiple instances of JIRA or use different task management systems for different projects.

"E-IT is obviously responsible for the IT environment and infrastructure, but it happens now and then that we also have some "shadow IT". Development teams are using IT off the radar, sort to say." (Respondent 3)

Similarly, the common development platform dealt with the issue of multiple servers for source code management. Establishing the common development platform allowed to optimize software development and maintenance in terms of supportive tools and methods, and to avoid having isolated development infrastructures with overlapping functionality for different P-IT development teams.

Another important issue is license management services - to take one example - for product licenses (in P-IT) and software licenses (in E-IT) is. Can both service types be based on the same technical infrastructure and use the same encryption and logging services (to take just two examples)? If so, why not define common EA elements on application architecture level for P-IT and E-IT?

A core challenge for Husqvarna to handle the integration of P-IT and E-IT is to handle the bimodal dimensions of the IT lifecycle which is closely related to the concept of bimodal architecture.

"Product owners are sometimes caught in their traditional way of working. They have their product model, you have to pass those all the toll gates in that model. That is an obstacle I think." (Respondent 1)

"Historically we have a product-centric organization where we have a planning period of one year at a time, with a specified budget each year. At the end of the year we are expected to have a product out on the market. With the new types of products, the development team is developing a service or system that is always available, which is different from when you develop a product: you put it on the shelf with more or less no cost. You could fire the entire development team after that if you like, as you still have it on the shelf. Doing that for a service or system that you have

to operate with the whole backend is not working. Especially when we are talking about mobile apps, for which people are expecting updates. Therefore, even for a minimum level of maintenance for a system we need to calculate for that. The way that this has been done before is that the maintenance would be included in the next year project, which therefore most of the times will not be budgeted correctly." (Respondent 2)

The E-IT dimension (Mode1), designed for stability, efficiency, and low cost, which is closely related to traditional EAM. P-IT on the other hand (Mode 2) is constituted by development projects that help to innovate or differentiate the business. This requires a high degree of business involvement, fast turnaround, and frequent update, the so-called rapid path to transform business ideas into applications. To handle this Husqvarna is implementing DevOps Teams designed for agility, rapid development and short time to market. In Husqvarna these two modes (Mode 1 & Mode 2) are closely related to the concept of two speed architecture as presented earlier.

"It is quite a pain when we have this funding process that goes in collision to our agile way of thinking. So, if we are talking about this bi-modal development process – we (P-IT development team) are working in mode 2. But almost every process is defined for mode 1 so we have to come up with creative solutions every time. We try to find a way to fund our way of working agile and follow the guidelines for the Husqvarna process, the funding process." (Respondent 4)

Today Husqvarna experience a clear tension between Mode 1 and Mode 2 and they give testimony of several more specific challenges in relation to the bimodal dimensions of IT, such as governance and responsibilities between research and development and IT, how to increase speed and suitable methods to support agile teams. Also, how to balance governance and support between P-IT and E-IT, lack of frameworks to describe IT technology stacks for IoT and digitalization.

"There is a reference architecture on our enterprise level, but it is not so concrete: there are a lot of boxes and names right now, but there are not much that are useful for implementation." (Respondent 1)

There is also a need to handle legacy systems during the transformation into the digitalized enterprise. An example here is using certain technological solutions or parts of systems, which are not optimal for the current or planned P-IT.

"VPN has been one of the parts of legacy discussion. We have discussed that we shall not have any VPNs but due to legacy we needed to set it up." (Respondent 2)

5. Discussion

In this section, we discuss the research questions in connection to the empirical data. Our reflections are occasionally supported with interview quotations.

5.1 Elaboration on research questions

Does the architecture of P-IT in the case study show similar levels as known from traditional EA? The TOGAF levels previously introduced will in this section be considered as "traditional" EA levels. On the technology architecture level, we found different hardware/software architectures which define platforms and reuse concepts for electrical/electronic control units in the products, sensors and actuators connecting to them and communication or networking components. Furthermore, the communication networks connecting the products to the backend network or the Internet could also be considered as part of the technology architecture.

One issue on technical level is related to the technical decisions that affect several actors involved in P-IT development. This is particularly related to software components embedded into the physical products. Here it might become problematic for P-IT development team if Research & Development (R&D) takes the lead and takes the complete responsibility for decision making regarding protocols and implementation of details in the product software. There is obviously a need to establish a more active dialog between these teams.

"R&D decides what protocols and communication standards they would like to use for the products (lawn movers). When we (P-IT development team) get involved we want to have more to say what kind of software we want to use on the movers, because it would make it easier for us in the IT solution and if they disagree we might have a clash." (Respondent 1)

One example of the existing E-IT not being able to provide suitable support for P-IT is identity management software solution, as it was not planned for customer accounts created to use the app.

"We have an internal enterprise identity access management suite from, for example, IBM. We manage all our consultants and employees there. We also have included dealers accounts to that system that are our customers. As long as we have limited scope of the number of identities, the financial model scales good enough. But if we introduce consumers entities then the volumes will take off and we will not be able to use that system from financial standpoint, I do not think technically either." (Respondent 3)

On the data architecture level, we found different data structures present in usage scenarios of P-IT, but not all of them are fully stored in the product. The most prominent data structures are configuration and license information for the actual product in use, usage data collected during operations (operation time, operator ID, temperature, power consumption and other usage information of the device) and data structures for representing evaluation results of the operations data (indicator development statistics, triggered alarms and notifications, rules, etc.). Parts of the data are captured in the physical product or base stations made for forwarding the data. Other parts are stored in the cloud. Future scenarios also include streaming of real-time data via the base station to the cloud.

"The data from the product is collected and transferred into the development team's back-end. So far there is no BI level, so it is more or less raw data. Based on the data, they have some mechanism in place for giving suggestions on predictive maintenance." (Respondent 2)

The application architecture showed a separation between external services made for customers, the back-end services for the physical products and the services built-into the physical products. While external services are quite unified across the different product categories (ownership and warranty registration, archive for manuals and technical documentation, statistics and alerts), the back-end and built-in services are dependent on product categories. An example is to lock/unlock the physical product using an app on the smartphone or smartwatch. This requires a corresponding backend and built-in services which is not appropriate for all types of products.

The business architecture basically is defined as soon as the customer value and the use cases that have been designed and implemented to deliver the customer solutions. These values and use cases have been documented and are maintained, but in the conventional meaning of the business architecture they do not cover the functions and processes of Husqvarna Group for their customers.

One aspect of business architecture that requires further consideration and integration between P-IT and E-IT is customer support. Customer support is currently managed in a quite fragmented way and the actors involved are not interconnected. There key questions to answer in this respect are *Who owns customer experience?* and *How customer experience should be handled?*

"We have a Brand and Marketing department that is responsible for branding on public sites and in social media. They have graphical guidelines for how the brand should be communicated through colors, fonts, designs and everything like that. But that is for marketing and for public websites. Then there is another department that is responsible for design of our products. You would expect those two departments to be aligned on what should be the overarching brand experience, they should agree in this. However, when it is a digital product or digital interface that needs to be defined, it is closer to the brands and marketing team but that is not the typical kind of delivery they do. But at the same time, it is product deliverable, so it is a clash with product development team and user interface designers."(Respondent 3)

Table 1: Summarizes the results from discussion of the first research questions.

Architecture Layer	Content
Business architecture	Not explicitly defined as architecture; made up by customer value and supporting IT solutions
Application architecture	External customer services, backend services, services built into the physical products
Data architecture	Operations data, evaluation and statistics, configuration data
Technology architecture	Embedded systems architecture, communication components, infrastructure components

Are there existing or potential commonalities between product-IT architectures and EA? On the technology architecture level, most parts of the product's technology, i.e. the hardware/software architecture and communication interface, seem not to be relevant for an EA integration. However, when it comes to the communication infrastructure it can be expected that we will move from point-to-point to mobile edge computing (MEC) which would affect even the enterprise architecture. MEC basically adds additional functionalities to 4G mobile networks which basically deploys computing services at the access nodes.

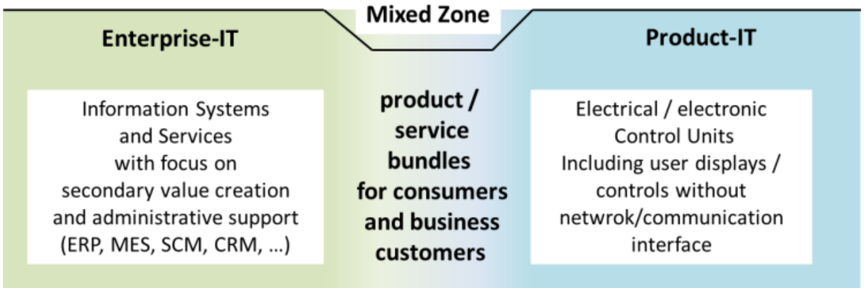

Figure 3: Summary of results for research question 2

What are the central roles in product-IT management and are these roles comparable to the roles in EAM? The roles identified in the analysis are product owner, enterprise architect, system architect and service delivery manager. The product owner is responsible for managing the feature of a product for the different target groups, the version and roadmap planning for implementing the features and the operation planning. The service delivery manager takes care of operations, maintenance and transition between service versions. Enterprise architect and system architect design the overall system, one with the focus on backend and enterprise integration, the other with focus on IT components in the product. The enterprise architect has as a part of his role to coordinate the enterprise architecture integration. Although this pragmatic arrangement works well, it is considered by the use case partner as not pro-active enough, i.e. a general road mapping for joint E-IT and P-IT development is missing.

The data revealed the importance of an "insider" role working with enterprise architecture questions in close dialog with digital product teams. This role would be providing architectural guidelines, reference architecture to the digital product teams for implementation. The risk of reference architecture being too abstract should be avoided by facilitating an open dialog with the product team.

"Enterprise Architect would like to think ahead of things, but it is really good to understand that we have to focus in a short time, we have to deliver. That is the gap which needs to be closed to succeed." (Respondent 1)

"When it comes to the reference architecture and what the teams are implementing, it is a big gap. So far there is no way to make the reference architecture more concrete. For example, what are the different domain services that we need to build our services, that is somewhat missing." (Respondent 2)

What are the cooperation processes between EA and P-IT architecture management? The cooperation processes in the case study data so far do not give a complete picture. We found processes directed to those embedded systems in the product including electrical and mechatronic parts which only communicate with other internal components in the product by internal bus systems or other mechanisms. Parts of this process are outsourced. These "P-IT only" processes are in the case study not considered as interesting for the overall EA, maybe except for the architecture for the control units.

The cooperation process between E-IT and P-IT calls for new financing mechanisms.

"The traditional way of dealing with IT cost would be to have the balance in the different divisions and on top of that to take IT cost and split it. Then it would be subtracted from all the divisions. Now we are trying to allocate the cost directly back to the product owner for everything, so product owners take the cost for the IT infrastructure for their services. That will also make the product owners willingly to pay for development efforts and improvement efforts and would reduce the cost." (Respondent 2)

Furthermore, we found processes for components in the physical product connected via radio networks, e.g. for communication to the base station or other devises. Here, the process of developing new P-IT components, versions or features is well-defined at the use case partner. This process also includes steps aiming at the coordination of the development of services on an enterprise level with the responsible enterprise architect involved. Many of these processes are following the DevOps procedure model which includes the development of components and services and operations tasks. As there are services which have the potential to be shared with administrative parts of the EA, they can be considered as part of the "mixed zone" in the figure above.

6. Conclusions and future work

Based on an industrial case from a manufacturer of power garden products, this article discussed the issue of integrating P-IT into EAM. The literature study performed as part of this work indicates that this subject is widely unexplored in academic literature but very important for industry. The Husqvarna case shows that industry implemented pragmatic solutions for dealing with different dimensions of P-IT integration into EA. Although these solutions work in an acceptable way there is a clearly expressed demand for improvements and the statement that many of the EAM standards do not work in this context.

Furthermore, our investigation showed that traditional enterprise architecture layers are suitable for structuring P-IT but not optimal for this purpose. More refinement layers are required, e.g. by identifying a "mixed zone" between P-IT and E-IT which is structured differently. The borderline between E-IT and "mixed zone" disappears more and more by integration of mixed zone and E-IT services. In P-IT some architectural parts remain non-connected which essentially are the isolated control systems for the outdoor power products with their machine-focused use interfaces. The mixed zone can roughly be divided into layers according to the enterprise architecture but should considered from a more fine-grain structure. Customer support should be considered as one of the central aspects when defining services for a "new" business layer, as the customer point of view is crucial for P-IT generating business value. Here, issues like customer onboarding, customer support and taking an end-to-end view for enabling a joined-up customer experience can be named as important.

In addition to the EA layers, there is a need to refine the EAM and included governance mechanisms. New financing mechanisms and processes of working would need to be defined, considering the new value generating role of IT, which originates from P-IT side and goes beyond the traditional supportive role that E-IT has.

The Husqvarna case has clearly shown how they in a pragmatic way have dealt with bi-modal processes and two speed architecture and the implications of this. It is quite evident in this study that a more systematic approach to handle this would be appreciated, and especially in relation to the traditional EA layers. Smart, connected products require enterprises to build and support an entirely new technology infrastructure [1] and where their suggestion of a new technology stack looks promising. In this structure they suggest an integration of P-IT and E-IT through three interrelated layers including, Product Cloud, Connectivity, and Product. These three layers are then interrelated with three dimensions of digitization, Integration with Business Systems, External Information Sources, and Identity and Security.

The main limitation of this work obviously is that it is based on only one industrial case. We performed an exploratory case study meant to contribute to a better understanding of the problem. From this perspective, this limitation is not severe at this early stage of the work. More case studies are of course required to get a more complete picture. Future work will include continued data collection in the Husqvarna case study. Interviews with more actors involved in the garden power products and on the E-IT side are planned. Furthermore, we will start a second case study in cooperation with the second industrial partner in the research project, Skye Consulting, which will be directed towards turbine manufacturing of one of the world leading companies in this field. On the theoretical side, future work will include an extended literature research.

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