Organizing in The Age of Digital Product Platforms: The Work of Integrated Vehicle Control Engineers

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Abstract. As flexibility and generativity of digitized information continuously afford new possibilities, a significant challenge for organizations becomes pinpointing practices that are befitting from various aspects. Two overarching digitization eras have so far determined the greatness of the challenge for organizations; 'computerization', and 'the Internet'. Today, a third era of digitization is marked by the emergence of digitized products. As increasing numbers of code line and software are being incorporated in previously physical products such as cars, they can be used as complete products on one layer, and simultaneously turn into platforms enabling other firms to develop and integrate new components, content, or services on another layer. As digital product platform's multiple design layers need to be open to various applications and agendas, their development requires new justifications and approaches for organizing work. By applying a Neo Socio-Technical Systems frame of reference on the work of engineers as they engage in developing digitized products, we 1. discuss changes of work and organizing along three eras of digitization, 2. provide a rich empirical instance by identifying what steps engineers take in preparation for developing digital product platforms, and 3. discuss the implications of these steps for the literature on practice and organizing.

Keywords: digital product platforms, digitization, work structure inheritance, Neo-STS.

1 Information Digitization and Categories of Change: An Emerging Research Agenda

With the advent of digitization and its accompanying globalization course, the 'what's and 'how's of work are inherited from rationales that extend beyond the managerial imperative in a single organization (Winter, Berente, Howison and Butler, 2014; Yoo, Henfridsson and Lyytinen, 2010; Tilson, Lyytinen and Sorensen, 2010). As 'flexibility'

and 'generativity' of digitized information continuously afford new possibilities, a significant challenge for organizations becomes pinpointing forms and kinds of practice that are befitting from an economic, ethical, safety and security stance (Brynjolfsson and McAfee, 2014). Information Systems scholarship is prolific with research on how information technologies have both supported and altered work, and how organizations have responded to these changes (Alter, 2008; Vessey, Ramesh and Glass, 2002). The challenge is not new then; it is the scope of the challenge that guides organizations and consequently IS research into a new direction.

So far, two overarching digitization eras have determined the greatness of the challenge for organizations; 'computerization', and 'the Internet' (Yoo et al., 2010; Tilson, et al., 2010). With the emerging computing power, in the first era, organizational challenges were associated with improving the efficiency of internal operations and decision making. With the advent of net-enabled firms, in the second era, the focus was on how collaborative systems, knowledge management and e-business systems assisted competitive capability in a distributed network of firms (Yoo, et al., 2010; Tilson et al., 2010). The ongoing efforts for efficiency and flexibility brought by information digitization today is snowballing into the emergence of a third digitization era; the era of 'digital product platforms' (Yoo et al., 2010), with organizing concerns of its own (See Hylving and Schultze 2013; Svahn, Mathiassen and Lindgren, 2017).

Digital product platforms such as iPads or more recently autonomous cars, can be used as complete products on one layer, and simultaneously enable other firms such as traffic or weather agencies, or app developers outside the industry to develop and integrate new components, content, or services on another layer each of which can in turn expand the basic functionality of the product (Ghazawneh and Henfridsson: 2013, Yoo et al., 2010). For instance, developing autonomous functionalities in a car includes integrating technologies from two distinct industry fields; the automotive industry and the mobile robot industry (Jo et al., 2016). This integration process leads to the improvement of the car functionalities, as well as providing a platform for the mobile robot industry to improve its AI algorithms in general (Jo et al, 2016).

However, such integration processes also include the challenge of negotiating priorities and instructions among heterogenous firms with distinct expertise, interests, and concerns (Boland, Lyytinen, Yoo, 2007; Hukal and Henfridsson, 2017). One example to bear in mind is the substantial coordination and planning required for integrating automated functionalities in the car which rely on vehicle's main functionalities (Khare, Stewart and Schatz, 2016; Gao, Hensley and Zielke, 2014, See also Jo et al., 2016, Basarke, Berger, Rumpe, 2007). These automated services and functionalities are largely developed by heterogenous firms outside the automotive industry with expertise in, for instance, neural networking, deep learning or data mining, yet with little knowledge in the automotive area or concerns with vehicle safety (Jo et al, 2016).
Alongside with both the platformization of previously physical products as well as the formation of ecosystems consisting heterogenous collaborating firms, we formulate our research question as, "how do engineers form viable work practices when developing digital product platforms". Of particular interest is to identify what steps are taken both on the technical and organizational side to facilitate the grounds for turning products into product platforms, and creating ecosystems of collaborating heterogenous firms.

In addition to identifying these steps, we will also discuss what implications such steps and arrangements have for the literature on forms of practice and organizing in the third digitization era.

To provide a research context, we have selected the automotive industry as being involved in developing autonomous cars, i.e. a case in point for digital product platforms. By looking at the engineers' work as they develop product lines for autonomous cars, we provide detailed real-case examples of how the engineers' work reflects the technological characteristics of digital product platforms and how these characteristics are perceived to influence processes of forming functional work practices.

Our contribution by exploring this question is to address the practical implications of pervasive digitization for organizations involved in highly innovative product development. As could be anticipated, a practical challenge for these organizations is forming work systems that will support fast and adaptive product development in a thriving network of heterogenous firms (Tiwana, 2014, Hukal and Henfridsson, 2017). Our theoretical contributions include aligning the way we think about organizing with the current phenomena of interest in IS. This is arguably a prevailing call for Information Systems researchers as the phenomenon of interest in IS is a moving target, changing rapidly with changes in information technology (Gregor, 2018).

2 Research Setting

The OEM (original equipment manufacturer) we have selected as the setting for our study has been focused on a fundamental reorganization process that aims at reducing the decision-making hierarchy and promoting an upward development structure. The company's emphasis on shaping processes and structures in a bottom-up way have coincided with its investments in developing autonomous cars. Since making autonomous cars is still at its early stages, even for OEMs with a long record in the automotive industry, the work guidelines and development requirements remain largely undefined to this date. The focus on minimizing decision-making hierarchy and an upward development structure then appears to be inevitably fitting. Besides the promised benefits of reduced hierarchy and distributed decision-making, there are also draw-backs. The younger engineers who are mostly in charge of developing product lines for autonomous cars find it increasingly challenging to be left to their own devices when it comes to setting product requirements and establishing work procedures. However, they are also aware that, given the newness of the products they are developing, it is practically impossible to have clear goals and structures before product lines are actually developed and, that only in retrospect, it would be possible to refine goals, requirements, models and procedures.

A smaller part of this challenge is thus motivated by the senior engineers assuming a more supervisory role than being immersed in product development. A larger share of the challenge is however prompted by the unconventionality of the work required for developing product lines for autonomous cars. In this light, exploring how these engineering teams plan and structure their work to develop different products for autonomous cars sounds like a promising strategy for studying the organizing logics in

the era of digital product platforms. It should be mentioned that, by 'organizing logics", we are referring to the professionals' sense making processes as they reflect on the 'what's, 'how's and 'why's of their work. In our study, we focus on the IVCcore squad. 'Squads' are names given to teams assigned to developing specific products lines. IVC-core squad is the abbreviation for Integrated Vehicle Control team which exists in the company's software development division and consists of 8 engineers. To put it simply, IVCcore squad has been in charge of two major development lines since its formation. Firstly, the squad embarked on integrating the electric control units (ECUs) for three fundamental vehicle motions, including propulsion, steering, and braking in a single ECU. Secondly, the team will modify the ECUs to be eventually applied in autonomous driving (AD).

Given this description, we expect to see two types of logics and strategies for work within the team; 1. logics and strategies for working towards developing products that can be specific to any car in general, such as developing a single ECU for propulsion, steering and braking. 2. logics and strategies for working towards developing products that are specific to autonomous cars, such as developing interfaces for connecting the car to the Internet of things that allows external firms to use the car for their intended functionalities. This way, we anticipate the squad's work to present an exemplary shift in work practices and organizing logics that are necessary not just for developing de-fined products such as a car, but also organizing logics for developing digital product platforms such as autonomous cars that are open to future modification and application. Following the squad's work could therefore be a useful strategy for studying both work practices and organizing processes for developing digital product platforms, and for capturing a shift from previous organizing models. Having explained our motivations for selecting the work of the IVCcore squad as the focus of our study, we next explain our strategies for following their work.

3 Data gathering

Given the exploratory nature of our study, we have followed the work of other researchers who have adopted an iterative approach1 (Leonardi and Bailey, 2008; Henfridsson, Mathiassen and Svahn, 2014). Starting with initial interviews of mid-management and senior engineers, we acquired a preliminary overview of the company's agendas related to the development of autonomous cars. The initial interviews were mainly aimed at understanding what divisions of the organization were specifically dedicated to research and development of autonomous product lines and how the human resources and competences were distributed across developer teams. Based on these initial interviews, we were able to identify the key informants in divisions of interest who then directed us to the IVCcore squad. The observation of the IVCcore squad started in October 2018 and is still ongoing. The observation sessions include at least 4 complete work days weekly, and 1 day dedicated to an over-arching analysis of data that can be used for devising research strategies for the week after.

[1] The data gathering phases are described in table 3 in the appendices.

The IVCcore squad consists of 8 developer engineers all seated in the same office area without any partitions dividing them. This spatial specification allows them to engage in conversations constantly to brainstorm, troubleshoot or discuss issues related to their work. The first author who is conducting the observations, is seated in the same area with the team. As there are no partitions dividing the team members, it is possible for the researcher to both see and hear the team members performing their work easily. During observations, we write careful fieldnotes making sure to record not only the activities of the team, and the artifacts they use, but also the topics discussed by the team members as they engage in conversations to perform their work. These notes assist us to pose follow up questions and inquire about the tasks and challenges in the team. This strategy usually results in exploring new topics and areas of the squad's work that can be further explored. Relevant conversations are audio recorded and are subsequently analyzed by the end of each week. This research design as well as the spatial arrangement during observations allow for witnessing things as they occur. Our observations thus resemble what Hennik, Hutter and Bailey (2010) describe as "watching an unfolding drama unfold with characters, events and story lines" (p. 170).

By following the conversation topics among team member as well as their activities on a daily basis, we have been able to develop tentative tables that are intended for capturing phases of product development, activities, challenges, planning, and structure of work for the IVCcore squad (see table 2). To make sure that we have understood the observed activities and recorded all topics discussed in the group, we will conduct semi-structured interviews with the squad members where these tables are filled with the help of each interviewee confirming that both the observed topics are relevant and that the descriptions of technical issues in projects and tasks match the engineers work.

Table 1. The work of IVCcore based on phases of product development

What			How			
Phases to AD	**Goal**	**Task**	**Challenge**	**Planning phases**	**Order**	**Special to AD**

As is clear in tables 2, the phases of product development extend a storyline describing the product-related projects the IVCcore squad has been and will be taking on. The left half of the table presents what the squad does, establishing a narrative history for the team's work which can help outline the key properties of order and structure (Van de Ven and Huber, 1990) as the team proceeds in developing various products lines for AD. The right half of the table indicates how the projects and tasks are planned for. Each member of the squad will be scheduled for two in-depth interviews; one interview dedicated to what the work entails and one dedicated to how the work is structured and planned for. The interview durations range among 60- 75 minutes. Once the interviews are done, there will be 8 tables -developed through 16 interviews- illustrating the work

of IVCcore squad based on the way each interviewee has framed and phrased their work.

4 Data Analysis

By focusing on forming the interview tables, we intend to make the details of our observations and interviews transparent. This method helps summarize the most prominent themes of our observations and makes the interviewees' own classification of events clear, allowing us to follow a "disciplined pursuit and analysis of the data" (Sarker, Xiao and Beaulieu, 2013). In the first analysis phase, the 8 tables will be compared and contrasted to formulate a single table that is illustrative and comprehensive of the IVCcore's work based on all 8 interviewees. This is the inductive phase of the analysis where we emphasize telling a story in detail and avoiding the risk of missing parts that lie outside the scope of a theory (Walsham, 1995).

The second phase of analysis will include looking for a shift in the logic and strategies of structuring work as the team focuses more on the development of functionalities for AD. As clear in table 2, an important probe during interviews has been whether any part of what they are doing is necessarily related to making autonomous cars and not a traditional car. The purpose of this probe has been to distinguish between activities or forms of practice which are accommodating towards future adaptations and applications by multiple users which are unclear and uncoordinated at the time of development. In this analysis phase, we intend to benefit from theoretical concepts and frameworks that help spot a shift in organizing forms and strategies in our descriptive table based on the characteristics of digital product platforms. By doing so, we hope to move beyond a mere description of events and bind the empirical phenomenon to the cumulative research on organizing logics, and thus aim for a more compelling story of our digital age (Henfridsson, 2014).

5 Results

The events identified at the field during our time with the IVCcore squad, through both observations and interviews, can so far be categorized into 3 overarching courses; 1, developing an integrated vehicle control unit for the three main motions of the car, i.e., propulsion, steering and braking, and 2, modifying the architectural model for the integrated control unit, and 3. revamping organizational arrangements to support the current work. These three courses of action each present a shift in the following aspects of work: 1. A shift in work practices, 2. A shift in design architecture, and 3. A shift in the organizing processes. As our analysis shows so far, each of these shifts imply respectively a change in the kind, scope and meaning of work and organizing. We will thus discuss how each of these three courses of events prepared the organization to turn the vehicle control software into a platform and how these preparatory steps are configuring new forms of practice and organizing.

6 Appendices

Table 2. Data gathering phases

Stage	Method	Informant source	Topics	Purpose
Introductory	Open-ended interviews	Organizational management, organizational coaches, Software division mid-management	-Reorganization processes, -Division of work, -R&D projects for AD	Gain knowledge of divisions dedicated to developing AD product lines, & of distribution of human resources and competences across developer teams
IVC-core1	Observations Oct 2018-June 2019	IVCcore engineers	Daily tasks and routines, challenges	Find themes, formulate interview guides, develop a narrative map
IVC-core 2	8 Semi-structured interviews	IVCcore engineers	Project, phases, goals, tasks, challenges	To capture *what* the team does to prepare or develop AD product lines
IVC-core3	8 Semi-structured interviews	IVCcore engineers	Planning procedures & structure, decision-makers, specification of requirements for projects	To capture *how* the team prepared for working in different projects and phases

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