VIRTUAL OBEYA: COLLABORATIVE TOOLS AND APPROACHES TO BOOST THE USE OF SIMULATORS IN CONCEPT DESIGN

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ABSTRACT

This paper presents research results from a study on user requirements for in-context lean engineering collaboration. The study forms an integral part of multidisciplinary research on collaborative tools and approaches addressing sources of waste in lean engineering in the European large-scale integrating project LinkedDesign.

The results are guiding the research and technology development work on a Virtual Obeya; a digital, improved version of the Obeya collaborative arena concept pioneered by Toyota and later adopted in a range of companies and industries using lean engineering principles. Topics of particular interest include geographically distributed project teams collaborating closely on concept and product development, and also sharing of models, tools and techniques in collaborative team environments - including simulators and their use within such teams. The paper summarizes project objectives for the Virtual Obeya, results from an analysis of frequently observed sources of waste in collaboration and finally selected approaches for improving collaborative performance in engineering teams.

INTRODUCTION

Teams involved in the development of new products, technologies and concepts, face numerous challenges. A number of technologies, engineering approaches and collaborative work patterns add to these challenges, but they also represent new opportunities and potential sources of competitive advantage for companies willing to explore new approaches and new ways of executing projects. Among these, the tendency towards executing split location projects with global teams spanning multiple geographic sites, is important. Another key trend is the use of advanced modelling and simulation tools to reduce of the need for physical models in the early stages of the engineering process, thereby making large savings both in cost and in time consumption.

One of the challenges of geographically distributed project teams is that certain new and productive work methods are difficult to implement, as some aspects of these methods, in their proven, original form, are closely tied to the team being collocated. The use of the Obeya is one of these areas, as this concept was originally developed to support collocated rather than split location engineering teams.

Obeya is a term used for a "large room" originally connected to project work in the automotive industry. Its origin is in the G21 project at Toyota in the 1990s, a project which led up to the first generation Prius. At the onset of this project, the Chief Engineer felt that he lacked the necessary authority to make the optimal decisions, and thought he could be overrun by experienced discipline leaders in a way that was not optimal for the project as such. He therefore needed the support of the other discipline leaders whenever he had a decisive discussion with one of them. In order to achieve this, he instituted the "large room" – Obeya in Japanese – as an arena for all his discussions with the discipline leaders. In this room, the other discipline leaders would be present, and documents and data would be available to all [Aasland and Blankenburg, 2012; see e.g. Liker, 2003; Morgan & Liker, 2006; Osono, Shimizu & Takeuchi, 2008 for an overview of collaboration and management principles in Toyota, the company that pioneered the Obeya concept].

LinkedDesign (Linked Knowledge in Manufacturing, Engineering and Design for Next-Generation Production) is a European large-scale integrating project with 13 partners from 7 countries. The main output of the LinkedDesign project is the technology platform LEAP (**L**inked **E**ngineering and m**A**nufacturing **P**latform), currently under development. This platform will provide an integrated, holistic view on data, persons and processes across the full product lifecycle.

An integral element of the technology platform LEAP is the Virtual Obeya being developed in one of the Research and Technology Development work packages of the project ("WP5: Collaborative Environments and UI Concepts for Context-driven Engineering"),

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exploring more effective and efficient engineering collaboration. The research supporting the development of the Virtual Obeya combines semantic UI principles, Active Knowledge Modeling [AKM; Lillehagen and Krogstie, 2008] and a context based approach to enable context-driven, activity-centric, dynamic and interactive visualization of engineering knowledge, information and data with high relevance to and between multiple engineering roles, including simulation [Kristensen et. al., 2012].

The LEAP Virtual Obeya is a front-end concept in the LinkedDesign project; the user interface and navigation that enables and supports the close contact and process-oriented knowledge exchange between experts of different working domains. The LinkedDesign front-end provides context-driven data access and collaboration support for teams involved in engineering and simulation tasks, as indicated in the upper part of the figure below.

LEAP is designed to be user centric rather than information centric. To foster collaboration between users across different disciplines, LEAP will use and extend lean engineering principles and implement a collaboration workbench enabling effective internal and external collaboration.

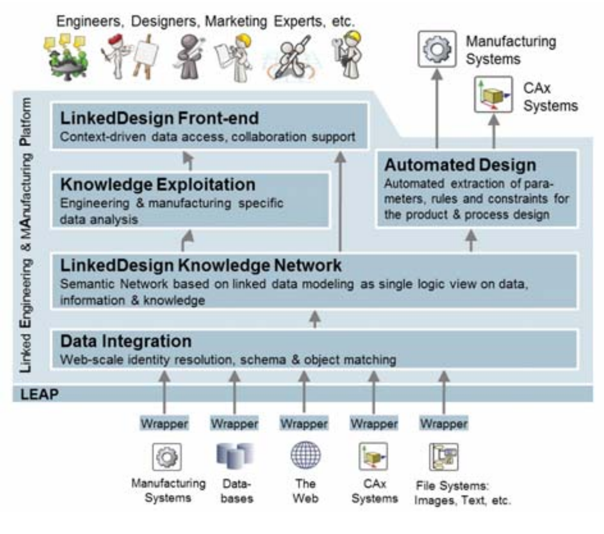

Figure 1: LEAP Overview

The Virtual Obeya is a new concept addressing certain limitations in a traditional Obeya, as piloted by Toyota and later adopted by many other companies and industries. The main objective is to accelerate value creation by applying new visual project management approaches to develop purposeful, powerful and simple tools for improving engineering team collaboration and communication:

The LinkedDesign Virtual Obeya offers a rich, relevant and context-specific front end supporting user collaboration across multiple tasks in a product lifecycle.

Specifically, the Virtual Obeya will be developed as a collaborative, context-driven user interface that enables user friendly access to all required engineering data and information sources.

With the Virtual Obeya, it is possible to alleviate some of the disadvantages of development projects involving engineering and simulation across multiple geographic sites. Models are very often a necessity in efficient development, and although physical models cannot be shared across sites, computer models and the tools and processes using them can easily be shared in real time. A particularly interesting case is the use of simulators, because they are highly beneficial, they are large, complex and expensive installations, and their application depends on expertise. Sharing models, simulations and simulator across the sites of a project opens new possibilities regarding efficient and effective product development and engineering design.

Thus, the Virtual Obeya has the potential to boost the real time use of advanced tools like simulators in split location engineering teams. Some of the key characteristics of the context-specific front end, that the LEAP Virtual Obeya represents, are:

- The focus is on value creation. This is achieved by providing high usability and in-context, easy and rapid access to aggregated knowledge level. Relevance, purposefulness and transparency are guiding principles.
- LinkedDesign has conducted research exploring rich interaction possibilities – suggesting an in-context feature set that is comprehensive within the scope of what is needed in any single situation, based on lean engineering principles. This includes – but is not limited to – simulators and their application as well as Knowledge Based Engineering; KBE [La Rocca, 2012; Sivertsen et. al., 2012].
- Furthermore, the LinkedDesign project has explored drivers for relevance, purposefulness and transparency across multiple tasks in a product lifecycle. This research is on-going and targeting provisioning of key insights, knowledge and information through visual project management – specifically interactive electronic task boards and integrated workflow environments.
- A Virtual Obeya for engineering collaboration and visual project management will be piloted, implemented and demonstrated through subsequent tasks in the LinkedDesign work package on Collaborative Environments and UI Concepts for Context-driven Engineering. The LEAP Virtual Obeya will support different levels of work coupling [Neale et. al., 2004].

The goal of this task is to collect and analyse integrated product development and concurrent engineering requirements (design and production data), and analyse lean product development principles based on semantics and front end value drivers.

EXISTING THEORIES AND WORK

Peter F. Drucker stated that task identification is the most important driver of knowledge worker productivity [Drucker, 1999]. This is highly relevant for discussions related to improving collaboration, as successful task identification in today's complex projects usually requires active involvement from several disciplines and roles. The inherent multidisciplinarity of today's complex products, services, projects and processes implies that collaboration is a cornerstone of knowledge work. In order to avoid poor decisions and quality problems that must be revisited, the most knowledge intensive processes require that all stakeholders with the power to veto a solution is directly involved in the design process.

Collaborative work environments can, if combined with today’s state of the art technologies provide an immersive, context-driven experience that systematically removes filters that get between the people working together and the task at hand. Through this, LEAP aims to enable a level of shared understanding where engineers and other knowledge workers can devote their full attention to what they are doing right now [Kristensen et. al., 2012]. While task execution is the primary vehicle or carrier of efficiency, user collaboration plays a central role in making sure multiple task execution activities are coordinated and purposeful in the context of overall project objectives. User collaboration can thus be regarded as a primary vehicle or carrier of effectiveness. As described above, Drucker [1999] ranked task identification as the number one factor determining knowledge worker productivity. Task identification precedes task execution, and more often than not involves user collaboration, particularly in a highly complex, multidisciplinary engineering setting.

Frequently Observed Sources of Waste in Collaboration

As described in the introduction, the Obeya room is an arena for rich interaction typically taking place between the Chief Engineer and the respective discipline leaders. In this room, typically all relevant discipline leaders would be present, and documents and data would be available to all. The team can discuss and work shoulder to shoulder whilst “co-navigating” complex, interlinked issues of a multidisciplinary character. How to mimic and preferably improve similar processes in distributed / split location engineering teams is of special interest.

The LinkedDesign consortium will explore processes similar to these later in the project to address commonly occurring waste in collaboration [Manyika et. al. 2009], when suitable concepts are ready for piloting.

Based on Manyika et. al. (2009) the following sources of waste have been identified in order of priority (based on input from all LinkedDesign project partners):

- Searching (highest priority)
- Misunderstanding
- Under-communicating
- Extra processing
- Waiting
- Misapplication
- Interpreting (lowest priority)
- Divergence (not a priority source of waste)
- Motion (not a priority source of waste)
- Translation (not a priority source of waste)

Approaches for Improving Collaborative Performance in Engineering Teams

Engineering collaboration is dynamic; it constitutes a mix of planned and ad hoc interactions as well as involving structured / formalized and unstructured / informal knowledge sources. Moreover, it evolves over time and co-exists in a large and growing number of different forms. Effectively supporting high-performance collaborative work patterns across a variety of different engineering contexts requires competencies for both individual knowledge workers and process owners. Moreover, performance is typically linked to collaboration on both a strategic and an operational level, both for work and reflection on work for learning and process improvement.

While technology is an important enabler of new collaborative work forms with attractive characteristics, technology alone is not sufficient to enable new, high-performance lean engineering practices. Broader change initiatives including smart combinations of people resources, technology, work processes, business culture and organizational models, are needed to fully exploit the value of collaboration. This is further complicated by the current lack of well-known, industrial frameworks for A) evaluating the impact of and B) systematically improving collaboration. There are however a number of tools and diagnostic frameworks that can be applied as decision support tools to make informed decisions that reduce risk and manage success factors for collaboration, e.g. Hansen [2009, 2004], Rosen [2007] and Mattesich et. al. [2001]. Succeeding with collaboration is a complex undertaking, and few companies succeed in exploiting the full potential of deep collaboration.

One of the main reasons for this is that collaboration is suffering from major coherency disconnects:

First, improvement efforts often fail because strategic initiatives and decisions are not followed up by operational measures – instating a policy that collaboration constitutes a main element in running the business does not lead to change unless it is followed by specific, clearly defined work practices that spells out how to use collaboration operationally to achieve business objectives. Collaborative engineering must not remain a loosely defined, ambiguous term – it must be given a clearly defined content.

Second, improvement efforts often fail because collaboration is seen and treated as something that is domain-specific rather than an enterprise-wide concept. This happens in part because the provision side has a strong position, and is able to influence terminology and shape managers' thinking on collaboration.

Collaboration does not equal a single collaboration tool or platform, or even a set of tools or platforms; indeed most activities in engineering companies today include some collaborative aspect(s). Unless these misconceptions are cleared and a proper understanding of how to facilitate and manage collaboration as a broad set of business activities is in place, it will be difficult to reap the full benefits of collaboration – and equally avoid misapplications of collaboration (that can reduce performance).

FINDINGS

Multidisciplinary engineering collaboration involving simulation activities is a very complex set of interactions and activities, and a comprehensive body of research suggests that this should be optimized on a system level [Kristensen and Kijl, 2010]. Current Obeyas commonly shared a set of limitations as indicated below [Kristensen et. al, 2012].

- Lack of distributed collaboration support
- Manual knowledge aggregation only
- No in-context adaptive GUI provision
- Only passive; no or limited opportunities to interact directly with underlying information architecture
- No information persistence between task boards / knowledge briefs
- Fragmented records; development typically documented across multiple sources and formats
- No simple import / export functions between physical (often paper-based) and virtual media formats

Characteristics of Traditional Obeyas

- Static, cluttered, no filtering
- «Low threshold» solution (high usability)
- Inefficient separation of computer-based «work» formats and physical «decision» formats
- No split location collaboration support

Characteristics of the LEAP Virtual Obeya (under Development)

- Semantics, dynamic filtering based on relevance criteria; context- and role-based knowledge aggregation
- Allows direct interaction with underlying information architecture – softer or no separation of «work» and «decision» formats
- Enables user collaboration over distance – with symmetrical or asymmetrical views, depending on role and context

The Virtual Obeya will consist of one or several "rooms", spaces or dashboards; each demonstrating a contextualized, purpose-driven aggregated representation of engineering information presented in a manner that aids effective and efficient processing of knowledge and development of insights.

Knowledge Acquisition for Knowledge Based Engineering (KBE)

According to Stokes [2001], tasks that have to be done on a rotational basis (routine tasks) cover nearly 80% of the overall design work. In consequence, to enable a quality increase while decreasing lead-time in product development means changing this ratio substantially. This leads to the field of Knowledge Based Engineering and respective research by La Rocca [2012]. According to La Rocca an extended definition of KBE is:

"Knowledge based engineering (KBE) is a technology based on the use of dedicated software tools called KBE systems, which are able to capture and systematically reuse product and process engineering knowledge, with the final goal of reducing time and costs of product development by means of the following:

- *Automation of repetitive and non-creative design tasks*
- *Support of multidisciplinary design optimization in all the phases of the design process"*

Structuring information and knowledge for easy reuse is the basis for any KBE system. Still, the knowledge and information that is entered into a knowledge system has to come from somewhere, and the Knowledge engineer is rarely experts in the field they are building a system for. For this reason, it is vital to have good communication with the domain experts.

One of the industrial partners in the LinkedDesign project, Aker Solutions, is systematically exploring new collaboration technologies and collaborative work practices based on lean thinking, as illustrated in the figure below.

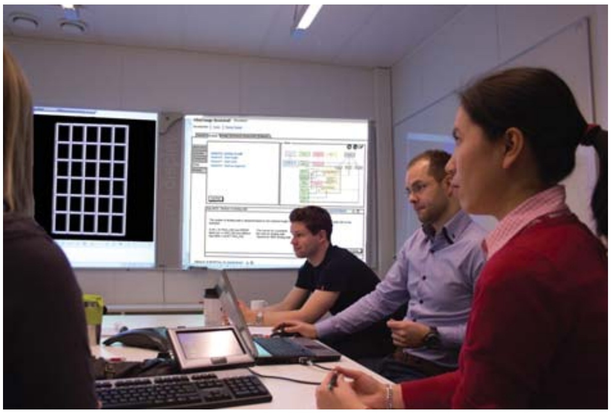

Figure 2: Aker Solutions Engineering Team (Image: Aker Solutions)

Today's procedure for the acquisition of knowledge is slow and old fashioned. It is based on one to one interviews, and hardcoding of engineering rules into rigid systems (or frameworks). The next generation of knowledge acquisition systems promises to radically change this. Collaboration tools will not only make it easier for the knowledge engineer to understand the knowledge the domain experts have, but the domain experts will also be able to collaborate effectively with each other, ensuring that the system gets the best information available. This will ensure that the LEAP platform has an excellent tool for lean, user friendly and collaborative knowledge acquisition.

In the context of LinkedDesign, one special topic of interest is the rather complex interface between typical automated design tasks, refer Sivertsen et. al. [2012] and typical user collaboration tasks, refer Kristensen et. al. [2012]. Consultations with the industry partner indicate that this interface is poorly understood, despite the fact that many frequently occurring tasks of significant importance can be described as taking place in this interface, as when engineers are shifting back and forth between automated design tasks and consultations with other stakeholders (user collaboration). In addition, classification can be difficult because tasks often involve elements of both categories. The following aspects are explored:

- **Automated design / knowledge acquisition as a consultative process with / between several stakeholders**: Today's engineering operations are largely multi-disciplinary. Discussions, clarifications, negotiations and decisions that occur in the interfaces between different phases and disciplines is an interdisciplinary value creation process, thus constitutes a large portion of typical engineering projects.
- **Automated design process as an iterative cycle between core automated design tasks and consultations**: In order to optimize productivity in current engineering companies, there is a need to integrate 1) typical formal engineering processes that are documented in accordance with formal rules in dedicated systems (here as in KBE), with 2) informal processes, which are documented more or less in a random fashion. The latter category is largely unmanaged, but nevertheless represents a large portion of the total interaction taking place, and hence represents a potentially valuable source of information if managed better. It is believed that there is considerable potential for productivity increases in coordinating these two categories closely. A rationale for these consultations should be provided, focusing on explicit value creation. Consultations could then be explored more systematically by using Nonaka & Takeuchi's knowledge cycle model (knowledge development as a cyclic spiral and interchange between tacit and explicit knowledge).
- **Waste reduction in collaborative KBE**: In accordance with lean principles, LinkedDesign targets waste reduction in user collaboration (also related to knowledge acquisition). Consultations with the industry partner indicate that effective and efficient user collaboration has the potential of acting as a catalyst in KBE – by simultaneously improving the quality of the process (reducing the risk of misunderstandings) and through acting as a process accelerator by reducing other forms of waste. This is discussed in further detail in Kristensen et. al. [2012].

DISCUSSION

Given the sources of waste identified and prioritized by the project partners, observations indicate that LEAP could add value by supporting a continuum from informal, ad hoc collaboration (low-threshold mechanisms for capturing knowledge created as a result of ad hoc creativity in teams) to more formalized engineering processes. A combination of pull- (search) and push-based knowledge provision mechanisms could represent added value in complex, multidisciplinary and collaborative situations such as "knowledge assists" where the person(s) in need of knowledge may or may not exactly know what to look for, how to retrieve it or what knowledge objects that could, semantically, be of interest or relevance. Selected benefits from the Virtual Obeya, based on initial investigations and industry partner consultations:

- **High usability** will be achieved by making the Virtual Obeya work on many levels. The simplest level will be to use it as a conference room with some added features, and this will make the threshold for using it low. Then – as experience is gained – more advanced functionality (shared walls, shared programs, shared data access, etc.) can be taken up, thereby turning the room into a functional Virtual Obeya.

- **In-context, easy and rapid access to aggregated knowledge** is a key to an efficient Obeya. During a project, loads of data are collected and generated, and it is easy for the project members to "drown" in them, so that they don't find what is needed without a lot of work. By structuring the data so that they can be retrieved based on context, this problem will be alleviated.
- **Rich interaction possibilities** will be explored during the project. We know that multitude of interaction modes is a characteristic of traditional Obeyas, and the virtual variety will have a challenge replicating these, but will also offer new possibilities compared to traditional Obeyas. Among the possibilities that must be explored is the use of shared virtual reality worlds. This would mean simulators that span the participating locations, with separate roles allocated to the participants.
- **Multi-role, multi-context interfaces** will extend the Virtual Obeya functionality to external collaborators that have access to the team space(s) using a regular PC, a tablet or even a smartphone. Graceful degradation and mobile first approaches will be explored to ensure access to the right knowledge in any context.

CONCLUSION

This paper presents research results from a study on user requirements for in-context lean engineering collaboration, as a part of multidisciplinary research on collaborative tools and approaches addressing sources of waste in lean engineering.

The results are guiding the research and technology development work for a Virtual Obeya, a digital, improved version of the Obeya collaborative arena concept pioneered by Toyota and later adopted in a range of companies and industries using lean engineering principles. Knowledge acquisition is the bottleneck for efficient KBE implementation and initial investigations indicate that collaboration techniques combined with the LinkedDesign "Virtual Obeya" concept looks very promising as an efficient tool for significantly enhancing the KBE knowledge acquisition process. This will be further explored in the later stages of the project, together with further integration with work processes in the demonstrator work packages.

A generic format for knowledge codification, as mentioned above, will also enhance the acquisition process as a common knowledge interface between domain experts, knowledge experts and the software engineers implementing a KBE system.

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