Using Semantic and Responsive Web Design Technologies for Cross-Device Interactions in Industrial Applications

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Abstract
Many industries today urgently call for applications that provide data and software services to mobile users on-site. Complex workflows spanning across different contexts of use, using different interaction devices and involving different people need to be supported seamlessly. Such collaborative cross-device interactions call for Semantic and Responsive Web Design technologies. In this contribution, we will explain why we need these technologies, how we may employ them and what we expect from their utilization. We will present a functional prototype that demonstrates the current state of our research and highlights the remaining challenges.

Author Keywords
Cross-Device Interaction; Responsive Web Design; Semantic Web; Industrial Application; Computer Supported Cooperative Work

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces: Graphical user interfaces (GUI)

H.5.3. Information interfaces and presentation: Group and Organization Interfaces: Computer-supported cooperative work

Introduction

Industrial applications pave their way from the office out into the factories, warehouses and chemical plants. Mobile applications offer services to support commissioning, operation and maintenance. Such applications are increasingly engineered with two main design objectives in mind. First, users shall be able to seamlessly switch between different target devices to accomplish their tasks. Depending on the task and context at hand, target devices may be office PCs, smartphones or even wearables. Data and software services may be provided anywhere and anytime (*on-site support*). Second, spatially and temporally separated people shall be able to form teams and jointly collaborate and support each other regardless of their current location (*remote support*).

These design objectives require highly flexible, dynamic, integrated and adaptive user interfaces. The integration needs to start already at the information level and must find its continuation on the interaction level. The large heterogeneity and complexity of industrial software tools and frameworks, the immense variety of the contexts of use as well as the specific requirements of professional use place high demands on performance, availability, safety, security and usability of industrial applications. Thus, the use of established, proven and well understood open software technologies instead of today's proprietary, platform and vendor-specific solutions is more than necessary. The speed of development of production processes on the one hand and of information and communication technology (ICT) on the other hand further calls for the use of long-term available and continuously developed, worldwide deployed standard technologies in combination with an explicit Design for Evolution.

Mission Statement

The use of global World Wide Web standards and technologies is the logical answer to these demands. In particular, the Semantic and Responsive Web Design technologies seem to provide solutions to the challenges in implementing appropriate future industrial applications. Breslin et al. have shown that Semantic Web technologies can be deployed to supply, production and order fulfillment processes [1]. Jetter et al. could show that cross-device interactions can be used to collaboratively perform a task in a central controlled use case [2]. Further, web-based platforms can be used to create cross-device solutions for collaborative, multi-role tasks in industrial settings as well [3, 4]. However, none of these works have really strived for creating integrated information *and* interaction spaces by combining the both technologies.

Our mission thus is 1) to create an information and interaction space for migratory, collaborative industrial applications; 2) to combine Semantic and Responsive Web Design technologies to realize such applications; 3) to use context information beyond screen properties to adapt the user interfaces to the users' needs; and 4) to integrate resulting applications into the existing industrial ICT landscape to prove the applicability of the approach.

The research presented in this contribution is grounded on a series of focus group workshops and participatory observations with industrial partners carried out over a period of several years. A Rapid Software Prototyping approach has been employed to create horizontal, functional prototypes on the target platforms (see e.g. [5]). Emphasis is placed on the use of established design standards and best practices.

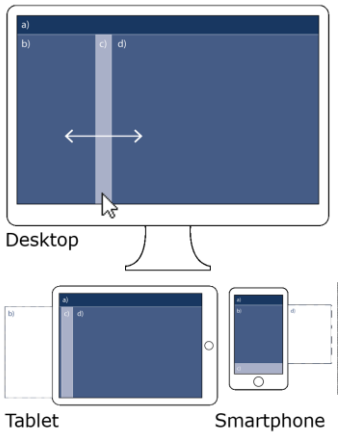

Figure 1: Structural layout for different device classes. Elements are re-arranging automatically.

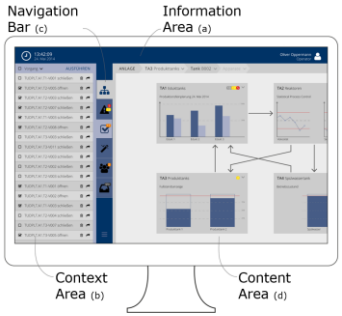

Figure 2: Description of the UI elements for desktop screens. Other screens adapt according to Figure 1.

Creative Vision

The creative vision of our research is an integrated information and interaction space that can be accessed by multiple persons with multiple roles using a variety of interaction devices in order to collaboratively cope with a complex task. Therefore, we aim at creating a responsive Computer Supported Cooperative Work (CSCW) system that automatically adapts to device properties, context information, user role and the task at hand.

The integrated information space shall provide shared access, flexible modification of both structure and content including the integration of external information spaces as well as a sophisticated revision management. All information models should be self-describing and explorable by computer algorithms. The integrated interaction space shall support a holistic responsive cross-device interaction providing appropriate views for various interaction devices. A role and task management system may adapt the content that is provided to the user. This includes access control but also automatic content selection and preprocessing as well as an adaptation of the visualization to the task and role at hand. The current task may be predefined by means of a workflow description or derived from the available context information. A job management system may further group data sets, states and conversations that belong to a particular job, thus creating a common context for collaborative tasks. Each user can be assigned to multiple jobs, and multiple users, possibly with different roles, can be assigned to one job as well. The application hence allows the user to switch between assigned jobs, so that a single, yet extensible, application running on multiple devices serves as common user interface for all users.

System Prototype

As a demonstrator, we are currently developing a prototypical CSCW system for operation and maintenance (O&M) in the domain of the process industries. The prototype provides cross-device interaction and activity-based presentation of information. The prototype supports target screens of three different device classes: desktop monitor, tablet and smartphone (Figure 1). Currently, the screen orientation is fixed to portrait view for smartphones and landscape view for the other two. The employed ZURB Foundation responsive front-end framework [6] automatically adapts the main elements of the structural layout (Figure 2) to the screen properties and contextual information such as geo-location. Three different roles have been considered: a shift leader that is responsible for organizational tasks and thus is mainly working in the office, an operator that is responsible for the supervisory control of the plant operation and thus is mainly working in a control room, and a maintainer performing the maintenance and service tasks on-site using mobile devices.

The prototype currently provides six different functions: a Process Operator Screen (Figure 3), a Batch Process and Workflow Modeler, a Task Organizer, an Alarms and Events List, a Chart Viewer and a Communicator including chatroom and dialer (Figure 4). The application might provide more than one view per function if the task varies according to the actual user role. For example, the shift leader may create and categorize tasks in the Task Organizer, whereas maintainers can assign themselves to existing tasks that fit to their particular skills and knowledge. Hence, the two roles require different data and dialogs to collaboratively accomplish their task being the organization of their maintenance tasks.

Figure 3: Process Operator Screen views for desktop and smartphone. The process data of the plant is shown in the Content Area (d) and can directly be modified in the Context Area (b).

Figure 4: Communicator views for tablet and smartphone. The Content Area (d) shows an ongoing conversation, the Context Area (b) (shown on the tablet only) provides the contact list with the conversation partners.

The information space is realized as a Linked Data (LD) cloud using standard Semantic Web technologies [7]. The LD cloud aggregates data from several proprietary software tools and exposes all distributed data in a uniform and self-describing manner. The main advantage of this approach is the simple confederation of heterogeneous data sources, both structured and unstructured. Having meta information as a first citizen data opens new perspectives for flexibility, extendibility and maintainability [8] of applications.

Future Research

Our preliminary findings indicate that great care must be taken in selecting appropriate Web standards and technologies. Hence, a first major research objective is to identify high-quality Web frameworks that meet the demands of the industry in terms of reliability, maintainability and long-term support.

Necessary foundation for holistic responsiveness is an integrated information space. We will continue our efforts to integrate the diverse data sources of an industrial IT landscape into LD clouds and to define common information models (*ontologies*) representing these data. In addition, we are working on data interfaces to LD clouds that meet the particular requirements of the industry with respect to performance, security, reliability and traceability on the one hand, and that perform well in combination with Responsive Web Design technologies on the other hand (see e.g. [9]).

The current prototype is based on a preliminary conceptual design framework. As a next step we will refine and generalize this framework, characterize and categorize the different possibilities for UI adaptation to the various factors, and draw up recommendations for their use and possible coaction. Further, we will investigate in the utilization of information on situational and environmental context to improve responsiveness. We will also integrate interactions which enable users, to easily push information and application context back and forth between devices in order to leverage effective working in multi-device settings, both in single-user and multi-user settings.

References

1. Breslin, J. G. et al. 2010. Semantic Web computing in industry. *Computers in Industry, 61-8*: 729-741.
2. Jetter, H.C. et al. 2013. Collaborative interactions in future crisis rooms. *Proc. JRC ECML WS*: 35-39.
3. Yang, J. et al. 2014. Panelrama: Enabling Easy Specification of Cross-Device Web Applications. *Proc. ACM CHI 2014*: 2783-2792. ACM.
4. Badam, S. K. et al. 2014. PolyChrome: A Cross-Device Framework for Collaborative Web Visualization. *Proc. ACM ITS 2014*: 109-118. ACM.
5. Ziegler, J. et al. 2012. Beyond app-chaining: Mobile app orchestration for efficient model driven software generation. *Proc. IEEE ETFA 2012*: 1-8. IEEE.
6. ZURB Foundation responsive front-end framework. Online: http://foundation.zurb.com/
7. Graube, M. et al. 2011. Linked Data as integrating technology for industrial data. *Proc. NBiS 2011*: 162-167. IEEE.
8. Ziegler, J. et al. 2014. Implementation and Operation of Collaborative Manufacturing Networks. *Collaborative Systems for Smart Networked Environments*: 197-208. Springer Berlin Heidelberg.
9. Graube, M. et al. 2015. R43ples: Revisions for Triples. *Proc. LDQ 2015*. CEUR-WS.