The benefits of 'In The Wild' studies for successful introduction of 'Bring Your Own Device' policies in the industry

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Abstract

Bring Your Own Device (BYOD) policies are becoming more and more popular in large corporations - in business, but also in industry. The possible benefits are reduced investment costs and improved productivity, flexibility and satisfaction of the users. However, BYOD policies raise new challenges for industry corporations in terms of device integration and evaluation strategies for the resulting IT ecosystem. In this contribution, we will briefly introduce those challenges. We will give generic recommendations on how to create (industrial) BYOD-enabled applications and systems. Finally, we will present some of our research results and our research agenda for BYOD policies in Industry.

Author Keywords

Cross-device interaction; Bring Your Own Device; Evaluation in the wild; Multi-device interactions; Distributed user interfaces, Wearable, Mobile

ACM Classification Keywords

Human computer interaction (HCI) :: Ubiquitous and mobile computing :: Empirical studies in ubiquitous and mobile computing

Figure 1: Mobile application to support industrial maintenance tasks on a ruggedized COTS smartphone.

Figure 2: Ubiquitous task support using multiple event-driven Android Wear apps on a COTS smartwatch.

Bring Your Own Device (BYOD) – What does it mean (for industry)?

Bring Your Own Device (BYOD) is an increasingly popular business policy which enables employees to use technology which was first deployed in the consumer market and which is owned by the employees themselves [1]. This allows the company to reduce investment and maintenance expenses for the devices and leads to increased employee satisfaction. One major concern, however is the increased number of potential security risks. Insecure connections, lost or stolen devices, malware and personal privacy issues of the device owner are major challenges of the BYOD approach [4]. These issues are subject to research and development driven by leading software companies, however. A second major concern is the lack of appropriate means to verify BYOD IT-ecosystems in industry-grade usability evaluations. The fragmentation of the system, the very short device and platform lifecycles and the quick evolution of interaction paradigms require an explicit design for evolution. Conventional lab and field usability testing faces practical limits when it comes to continuous evaluation on multiple user-owned devices with multiple operating systems that follow different interaction paradigms [2]. Alternatives approaches like remote usability testing still perform significantly below lab tests [1]. Yet, many questions of evaluating the usability of BYOD IT-ecosystems in the industry remain unsolved. In the process industries, where our research is settled, even further requirements may arise [6].

How to create (industrial) BYOD applications and systems?

According to our research experiences over the past years, we follow three basic principles in designing successful mobile and BYOD IT-ecosystems for industry corporations. First, we largely follow the design philosophy and guidelines that come with the platform of the users-owned devices. This may require some restrictions of the accepted operating systems, vendors, versions or models of hardware and software (*Choose Your Own Device* policy). Following the update cycles determined by the platform vendors is crucial in order to not lag behind the state of the art. This is difficult because it sometimes means to redesign an application although the functionality is still sufficient for the task. However, the more the design of an application becomes outdated the more the users�do perception of non-functional quality attributes will deteriorate.

Second, we largely rely on the device and deployment ecosystem provided by the platform vendor. Most vendors offer specific solutions for industry users. One may adapt, enhance or even replicate the ecosystem if necessary, but this should be done transparently to the users. Complex corporate tasks often call for more sophisticated means for deployment and administration of the IT-ecosystem than non-professional consumers.

Third, we try to continuously evaluate BYOD-enabled applications and systems in real settings with real users imposing as few artificial limitations as possible. Ecological validity is crucial for usability / user experience evaluations when it comes to BYOD scenarios. *In The Wild* studies might meet the requirements of usability testing of BYOD IT-ecosystems. Study designs with mainly observational character or very limited targeted variation of independent variables or control of confounding factors, however, tend to be insufficient for industry-grade usability evaluations. Same holds for low-effort remote usability testing methods proposed in the literature.

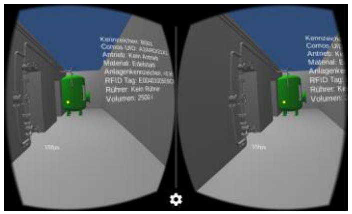

Figure 3: Unity-driven stereoscopic 3D VR application of a production site. The prototype supports interactive highlighting of assets and provides relevant asset data on-the-fly.

Figure 4: Wearable distributed user interfaces enable users to operate their mobile systems in settings where touch operation is unsuitable. They are also used to operate wearable systems such as VR systems.

Research Results and a Research Agenda for BYOD in Industry

Following the first principle, we largely rely on the Google Android ecosystem. We developed several mobile applications for common tasks in the process industry [4, 7, 9] (Figure 1) and extended them with sophisticated smartwatch support [10] (Figure 2). We also incorporated the Google Cardboard VR environment to virtually explore production sites (Figure 5). Largely relying on the design guidelines of the mentioned platforms we created cross-device applications that are easy to use for employees which are familiar with the Android ecosystem and that are easy to maintain for the app developers.

A main objective of a corporate application is to implement a certain, well defined business process or working procedure. Our *App Orchestration Framework* [7] provides a powerful engine to arrange sets of multiple apps (so-called *app ensembles*) based on BPMN models of the business processes and workflows (so-called *app orchestration*). Following the second principle, this framework is based on *Google Android*, thus the apps may be deployed via the off-the-shelf available *Google Play for Work* infrastructure. In addition, a *Jenkins automation server* has been extended to automatically create app ensembles for the user-owned device and to organize the deployment, either directly from the *Jenkins* server or from the *Google Play for Work* infrastructure. Currently, this infrastructure supports *Google Android* and *Android Wear* applications in order to create convenient cross-device interaction. In the near future, we plan to include *Google Cardboard* applications as well. This deployment infrastructure also provides comprehensive support for different input and output devices (so-called *wearable distributed user interfaces*) [8]. Using multiple versions of an application, each optimized for a specific interaction technique, app ensembles can be created that can be operated using very different interaction techniques (e.g. single-hand game controllers, keypads, gesture or speech input) according to the specific requirements of the user (Figure 4). This flexible multi-device orchestration allows for cross-device interaction under the highly adverse and variable working contexts of use where touch interaction is unsuitable.

In order to bring research one step further, we are developing evaluation strategies that allow for the subtle, yet controlled variation of independent variables and a sufficient characterization and treatment of the participants. The downside of ecologically valid settings is the evaluators' limited control over confounding environmental and situational factors. Following the third principle, one focus of our research is to develop control strategies and measures that reduce or govern confounding effects both in *In The Field* and *In The Wild* experiments.

In The Wild studies are limited in the possibilities to equip the evaluation environment with measuring instruments and in the ability to actively involve users in the evaluation of the system (e.g. by means of a questionnaire). For this reason, we aim at developing a device-centric measurement methodology including cloud-based logging (user input, system reaction), camera and audio data (e.g. for gaze and emotion analysis), bio-signals (coming from smart wearables), context information such as illumination, noise, temperature or weather data from the device nearby-devices in the IT ecosystem (e.g. smart home sensors) or other sources of relevant information.

Figure 5: Experimental facility in an industrial scale used to develop evaluation strategies and to do usability testing of mobile and wearable applications for the process industry.

Conclusion – Where are we now?

It is easier than ever to create complex cross-device interactions with commercial-off-the-shelf (COTS) products. There are device and service ecosystems spanning across a wide range of interaction devices, and which are widely used by millions of users every day. BYOD policies allow corporations to gain advantage from these ecosystems. We have developed appropriate deployment infrastructures over the past years and will continue this work by integrating novel COTS platforms such as AR/VR-systems, wearable systems and very large displays (e.g. power walls).

BYOD-enabled IT-ecosystems should continuously be evaluated *In The Wild*. In order to improve the performance of such studies, subtle means for targeted variation and elementary control of the most relevant variables as well as a user-independent, device-centric measurement methodology need to be developed further. Such means can be partly adopted from the area of *In the Field* research, but novel strategies and techniques need to be developed in order to take the specific characteristics of *In The Wild* studies into account. We are using a realistic industrial environment to improve and test our device-centric measurement methodology and evaluation strategy (Figure 5). This approach proved to be a good compromise between the rigidity of lab usability testing and the ecological validity of field testing, especially in domains such as the process industry, where real environments are adverse and dangerous. For large-scale summative usability testing, however, we will take our tool set and methodology and to go *Into The Wild*.

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