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Design, Development and Evaluation Challenges for Future Mobile User Interfaces in Safety-Critical Contexts

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ABSTRACT

The large variety of commercialized mobile devices, their reduced costs and their increased level of maturity makes them suitable for exploitation in an increasing number of contexts. However, the idiosyncrasies of interactive systems on mobile platforms raise many new challenges in terms of design, development and use. Such specific aspects include, dynamicity of contexts of use, interaction on the move and device management (e.g. power availability) that bring together many challenges and opportunities in every stages of the development process. This includes, for instances, multiple devices issues such as designing a single application to be used on various mobile (or not) devices as well as designing various applications to be deployed on multiple devices to be used by a single user. Several research contributions started to tackle these challenges but few of them address the additional constraints raised by safety-critical systems. While in the domain of interactive systems usability and user experiences are the first class citizens, safety critical systems designs call for well designed and implemented trade-offs between multiple properties such as safety, reliability... in addition to usability and UX. This position paper aims at presenting new challenges for designing, developing, evaluating and deploying future mobile UIs targeting at the domain of critical systems.

Categories and Subject Descriptors

H.5.2 User Interfaces

General Terms

Design, Reliability, Human Factors

Keywords

Mobile user interfaces; interactive critical systems; design and development processes

1. INTRODUCTION

The large variety of commercialized mobile devices, their reduced costs and their increased level of maturity makes them suitable for

exploitation in an increasing number of contexts. However, the idiosyncrasies of interactive systems on mobile platforms raise many new challenges in terms of design, development and use. Such specific aspects include, dynamicity of contexts of use, interaction on the move and device management (e.g. power availability) that bring together many challenges and opportunities in every stages of the development process. This includes, for instances, multiple devices issues such as designing a single application to be used on various mobile (or not) devices as well as designing various applications to be deployed on multiple devices to be used by a single user. Several research contributions started to tackle these challenges, from the design and/or development perspectives but few of them address the additional constraints raised by safety-critical systems. Several existing studies close to this topic are mostly dealing with wearable UIs for aircraft maintenance [1] [11] [14]. Their motivation are based on two main points:

- Aircraft maintenance activities are highly procedural and ruled, and they require the elicitation and application of relevant knowledge according to the diagnostic.
- Aircraft maintenance users (also called operators) have to perform actions and to manage information across several contexts.

These studies highlight the relevance and benefits of using cross-devices mobile UIs for performing monitoring and control activities on critical systems. Furthermore, recent integration of mobile devices in critical contexts (electronic flight bags in the cockpit replaced paper flight bags¹) highlight the interest of safety-critical industries for new mobile technologies, but also highlights the fact that some of the users of critical systems will probably interact more and more with mobile applications to perform their job.

While in the domain of interactive systems usability and user experiences are the first class citizens, safety critical systems designs call for well designed and implemented trade-offs between multiple properties such as safety, reliability, security, dependability, ... in addition to usability and UX. This position paper aims at presenting new challenges for designing, developing, evaluating and deploying future mobile UIs targeting at the domain of critical systems.

¹ <http://www.windowcentral.com/lufthansa-latest-airline-equip-pilots-surface-pro-3>

2. DESIGN CHALLENGES FOR MOBILE UIs IN CRITICAL CONTEXTS

Future mobile UIs will have to address multi-device interactions and collaborative work. Operators of critical systems will continue to interact with several devices and to collaborate with other partners of their organization. Conceptual frameworks have been proposed to start addressing these issues [16] [13]. We extracted from these framework design considerations that are relevant for discussion with regards to the particular case of interactive critical system design. Operators of interactive critical systems have particular procedures and tasks to follow. They have to reach a predetermined level of knowledge (declarative and procedural) before being granted qualification to operate with the systems.

- Future mobile UIs for cross-platform applications will have to address **appropriate composition** [16] of presented information and commands. In critical contexts, designers will have to identify which tasks are relevant to be migrated on which type of mobile device (wearable, handheld...) and which tasks are not relevant to be migrated on mobile devices.
- Future mobile UIs for cross-platform applications will have to address **task continuity** across several mobile UIs [16]. In critical contexts, this concept may not be relevant for all the tasks. Tasks are planned and related to a particular procedure and context. Designers will have to provide solutions to determine which tasks could be seamlessly performed across different mobile UIs and which tasks should be dedicated to be performed on particular mobile UI.
- Future mobile UIs for cross-platform applications will have to address **consistency** between mobile UIs [16]. In critical contexts, the designers will have to investigate whether or not it is appropriate to provide only fully consistent mobile UIs. Operators of critical mobile UIs will have to execute planned procedures and some of the procedures can be bound to dedicated contexts (routine activities, failure detections and recovery...) [7]. In order to ensure that there will not be ambiguities for the operator when performing a particular kind of procedure, the designer may have to provide distinct (non-consistent) UIs presenting different behaviors and compositions as a way to ensure that there will be no ambiguity for the operator concerning the current type of on-going procedure.
- Future mobile UIs for cross-platform applications will have to address **simultaneous collaborative interaction** [13]. The designers will have to deal with the coordination and communication activities between operators using mobile UIs. In critical contexts, activities can be highly influenced by time constraints, organizational issues and planned workflows between inter and intra organizational entities [6].
- Future mobile UIs for cross-platform applications will have to address **communality** of the mobile systems and of the information [13]. The designers of the mobile UIs will have to investigate how the usage of a range of mobile systems (glasses, watches, smartphones, tablets...) and associated UIs may fit with team

activities. How will these artifacts be shared amongst the team and how the other members of the team will be provided with the awareness of which member is using which mobile system (and for executing which procedure)?

- Future mobile UIs for cross-platform applications will have to address the extra activities related to the **monitoring of mobile systems and UIs**, which will come in addition to the planned operators tasks. Operators will have to ensure that their mobile systems and UIs are in a functional state while accomplishing their mission. Designers will have to deal with this additional task type: monitoring the vital parameters of all the mobile systems they use to accomplish their tasks (with for example a centralized way to get information about power level, connection status... for all of the in use mobile systems and UIs).

3. DEVELOPMENT CHALLENGES FOR MOBILE UIs IN CRITICAL CONTEXTS

Future mobile UIs will have to go through critical systems development processes. They will have to fulfill dependability requirements such as reliability and security. Solutions have been proposed to discuss possible backup strategies for mobile devices [1]. In order to discuss the application of these strategies to mobile systems and UIs, we extracted development issues that are relevant for future mobile UIs.

- Future mobile UIs and applications in critical contexts will have to fulfill **reliability** requirements. Several existing mechanisms from dependable computing field could be applied, such as **redundancy and diversity**. Designers and developers will have to investigate whether these mechanisms may be applied or whether they have to be tuned. For example, an operator may get granted 2 handheld devices for the same purpose (including a backup one). The backup one would be connected to the regular one so that each executed command on the first device is also automatically executed on the second. Then, in case that the first handheld device gets broken or nonfunctional, the operator can use the second backup device and continue her/his task **without loss of context** and with a **continuity of service**. Intra and inter devices redundancy concepts have then to be studied in detail for future mobile UIs.
- Future mobile UIs and application will have to fulfill **security** requirements. If operators of critical systems have their applications on the go, what will prevent malicious usage of their devices? For example, an on-call duty operator of a satellite mission, responsible for remotely monitoring the status of the satellite regularly during the week-end, could bring her/his mobile device to the mall and have the device stolen. What if the mobile UI enables to send telecommands to the satellite? Designers and developers have to investigate which commands and interactions should be available in the mobile UI according to the context of use.
- Future mobile UIs and applications will also have to address potential **conflicts and interferences** between professionals and personal devices [3].

In addition, to dependability requirements that future mobile UIs and systems will have to fulfill, developers will have to face the diversity of mobile systems and software platforms. Several approaches have been proposed and partially answer to this issue. Model-driven approaches have been coined to provide support for developing UIs for multiple devices (mobile or not) [10]. Software product lines have also been proposed to provide support for development of similar software products across devices [12]. And engineering techniques and framework have been proposed for developing distributed UIs [9]. But they are not sufficient to overcome new design challenges as they don't provide support to all of the here above mentioned designed and development challenges.

4. EVALUATION CHALLENGES FOR MOBILE UIs IN CRITICAL CONTEXTS

The software and hardware platforms on which the future mobile UIs will be deployed will have an impact on the performance of the UI and then on the **performance** of the users. Existing evaluation techniques will have to be enhanced to take into account the diversity of platforms across **multiple interaction contexts** [3]. In critical contexts, other properties (such as reliability of the system and of the operator) will have to be measured. The proposed evaluation methods will then have to also encompass techniques and tools which provide support for measuring them across multiple mobile UIs and contexts.

5. CONCLUSION AND PERSPECTIVES

This position paper presented design, development and evaluation challenges for future mobile UIs in critical contexts. Beyond the discussed issues, other key points will also have to be dealt with in order to propose solutions for deployment of mobile UIs in critical contexts. For example, will existing verification techniques (such as formal methods) be applicable to future cross-platform mobile UIs or will they have to be tuned? How the designers and developers will ensure that future mobile UIs are not more error prone than the existing UIs for critical systems? Will the existing training design and development methods be sufficient for these future mobile UIs?

6. AUTHORS' BACKGROUND AND INTERESTS

The authors have a long term experience in the area of interactive critical systems² including design and implementation issues of command and control systems. We have been working closely with main actors in the area of safety critical interactive systems including air-traffic management, aircraft cockpits and satellite ground segments. New mobile systems and UIs are not yet widely available in these types of systems as the difficulties in terms of reliability, dependability and certification limiting their use to non-critical aspects of the operation of these systems. However, increased maturity of the hardware platforms of mobile systems might make them amenable to a wider exploitation in these contexts. Our industrial partners (in these safety critical contexts) start to assess how far these systems are from the required dependability levels and how much their use would improve operations. Participation to the workshop would be beneficial to us by confronting our expertise in safety critical systems with potential research directions for future UIs in mobile contexts. It

is important to note that one of the authors has spent 8 years in R&D activities at Motorola Mobile Devices (see patents in the reference list [5][15]).

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² <http://www.irit.fr/recherches/ICS/index.html>