10.20378/irb-58445

Smart Ecosystems and the Impact on Mobile Interaction Design Methods

Claudia Nass, Konstantin Holl, and Christian Müller
Fraunhofer Institute for Experimental Software Engineering IESE
Fraunhofer-Platz 1, 67663 Kaiserslautern, Germany
{claudia.nass,konstantin.holl,christian.mueller}@iese.fraunhofer.de

Abstract. Smart ecosystems combine the Internet of Things, Services and Data by connecting several system classes. A crucial player are mobile apps aimed at covering the mobility requirements of the individual participants of such smart ecosystems. The characteristics of mobile apps call for tailored design approaches (e.g., addressing the complexity and size of such systems or the seamless integration in the daily life of people). With regard to the creation of the interaction design, we have identified challenges arising in the context of smart ecosystems and analysed some representative mobile interaction design approaches that can match these challenges.

1 Introduction and Motivation

The penetration of mobile devices in the daily life of people is growing rapidly [1]. People are using their mobile devices for shopping, communicating, and for accessing information more than ever. In some regions of the world, mobile devices are the main media to access internet services [1]. Especially in the context of smart ecosystem, mobile devices plays a very important role. Originated in the biology, ecosystems describe a system resulting from interacting organisms and their environment where organisms try to achieve certain goals considering their environment. Hence, smart ecosystems are the technical equivalent connecting information systems and technical systems with their environment. An example of a smart ecosystem is the modern integration of "mobility solutions that are able to jointly use different means of transportation smartly in order to solve a given transportation problem" [2].

Since mobile apps are an essential part of smart ecosystems, the impact on the mobile interaction design needs to be investigated. In this paper, we present some main trends of smart ecosystems and their influence in the mobile interaction design. We also explore two questions regarding the impact of smart ecosystem in mobile interaction design methods: (1) the interplay between challenges of smart ecosystems and mobile interaction design as well as (2) the requirements of these challenges on mobile interaction design methods and approaches.

2 Trends of Smart Ecosystems and the Role of Mobile Devices

Smart ecosystems enable a new way of life, allowing people to have constantly access to a wide variety of new services and products. Different scenarios, as represented in Figure 1, are examples of smart ecosystems: an autonomous car that meets you in the street and drives you to an important meeting, where business partners are waiting for you. A smart ecosystem would be able, e.g., to recognize the appointment in your calendar, to offer you the best transportation option, and to autonomous drive you to the current position of your partners. This means a system that combines emergent software (network of information systems) with cyber-physical systems (network of embedded systems) [3].

This is enabled just by the strong **digitalization of society**. The increasing availability of the Internet allows individuals to be in touch with the rest of the world almost permanently and ubiquitously. People are integrated into ecosystem processes, delivering information and consuming services through their daily routine, especially by using mobile devices.

The knowledge gained from people due to their interaction with smart ecosystems integrated into enterprise processes enables **mass customization** of products and services. The use of customised advertising when people are physically close to a store, also known as *geofencing*, demonstrates how user behaviour (elicited from their use of consuming online services and from individual movement patterns) is used by enterprises within their business processes. The use of integrated information technology allows enterprises to "provide individually designed products and services to every customer through high process agility, flexibility, and integration", i.e., mass customization [2].

Process attributes such as agility, flexibility, and integration can only be achieved with **high levels of automation or even autonomous systems**. This means, e.g., that production and logistic systems are prepared to respond to new demands. An example is the use of drones for delivering products (e.g., medicine) quickly and autonomously to a person, meaning the customer himself is becoming the new delivery address provided by the sensors of the mobile devices.

Therefore, information systems, embedded systems, and individuals form a **highly networked system** in the context of smart ecosystems that supports the continuous interchange of information and smart functionalities. Mobile devices empower this complex system because they allow permanent integration of people into the smart ecosystem.

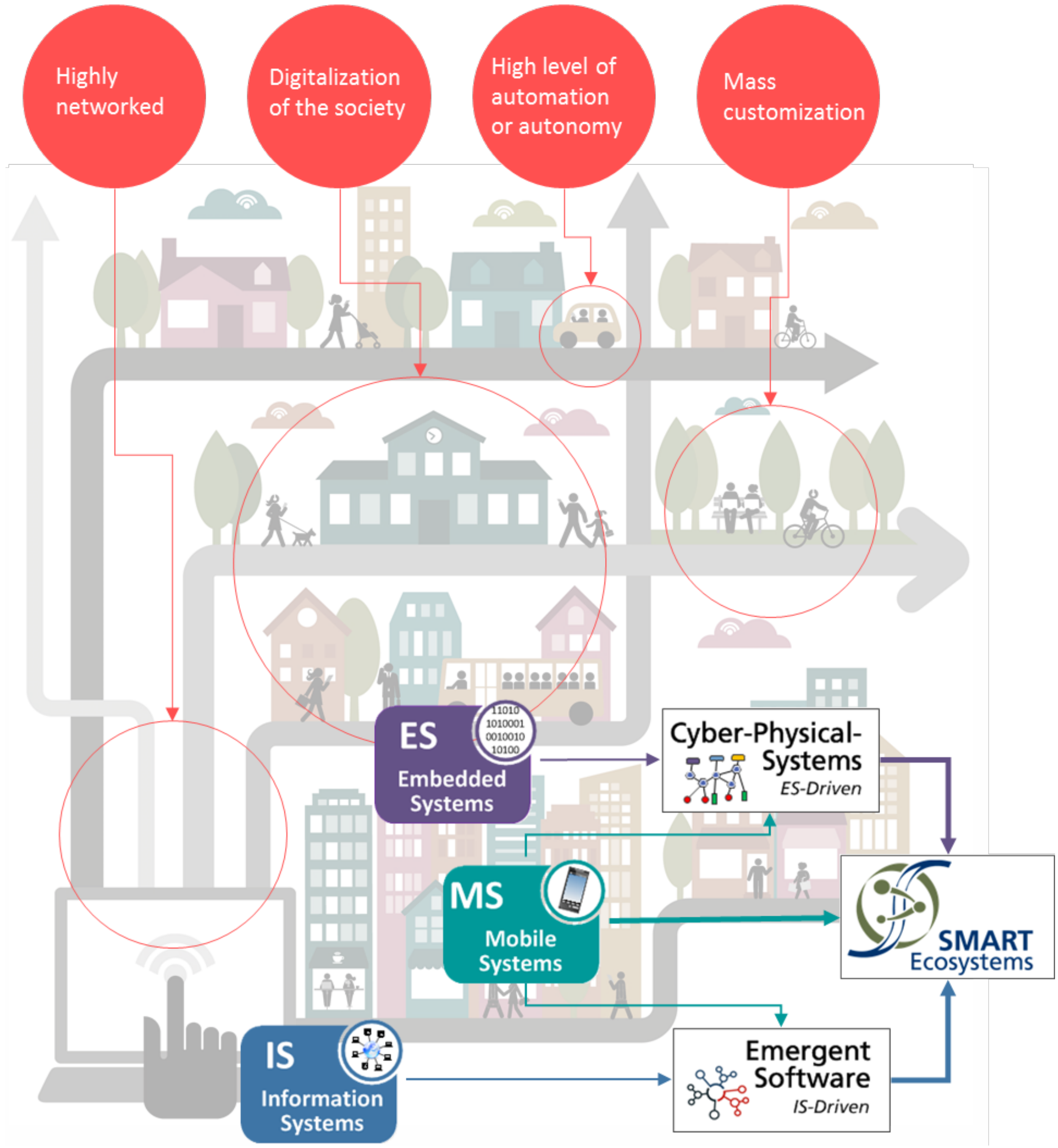

Figure 1. Smart Ecosystems and their Trends (adaption from Knodel and Webel [3])

3 Challenges of Smart Ecosystems and their Impact on Mobile Interaction Design Methods

Mapping challenges of smart ecosystems to common challenges of mobile apps beyond smart ecosystems requires first the consideration of general characteristics of mobile applications.

3.1 Mobile-specific Characteristics

Differences in developing and using mobile apps compared to classical software are often related to technological aspects. The main characteristics of applications on mobile devices such as smartphones and tablets according to Muccini et al. [1] are listed below, together with their impact on interaction design:

- **Limited resources**
The availability of energy and memory space, in particular, is lower for mobile devices than for classical desktop devices. This needs to be considered by the interaction design. For example, a permanently running feedback process has energy requirements that can be fulfilled by a desktop computer without any problems, but could lead to a battery drain of a mobile device that is unacceptable for the user.

- **User interface**
The main interface for the user interaction on current mobile devices is a gesture-based screen. It represents the primary input and output interface and offers interactions such as a variety of gestures using one or multiple fingers. However, the use of voice interaction and other sensors integrated in mobile devices cannot be neglected and has to be improved in high interactive scenarios. Methods for interaction design need to be aware of the range of interaction possibilities.

- **Context Awareness**
Besides the user interface, mobile devices use several sensors to capture context information depending on the environment of the device, such as brightness, connectivity, motion, or location. This context awareness can be involved in the user interaction and, as a consequence, it has to be considered as part of the interaction design.

- **Diversity**
The diversity of devices and operating systems results in high complexity of variants. Hence, a mobile app is often required to be compatible with different platforms using different interfaces. For the interaction design, this means that it has to handle aspects such as varying sizes of screens or even the availability of hardware buttons.

3.2 Challenges of Smart Ecosystems

Considering the mobile-specific characteristics together with the trends in smart ecosystems, presented in section 2, lead to a set of challenges that impact mobile interaction design. To answer our research question, we need to analyse if the current methods for designing mobile interaction are able to support the development of mobile apps in the concrete context of smart ecosystems, if there is a demand for adapting general methods for designing mobile interaction, or even developing new methods for the context of smart ecosystems.

The first main challenge presented by smart ecosystems involves the **complexity and size** of such systems. Nowadays, the design of mobile apps includes not just the interaction with the mobile app itself but also the whole experience with the service. Information volume, interaction intensity and availability, and cognitive load are aspects that have to be considered when designing new mobile interaction.

Additionally, we have the seamless integration of the real world with the digital world, i.e., the **integration of heterogeneous systems**. On the one side, there are information systems that process and control the interaction of the user and, on the other side, there are physical objects in which sensors and embedded components influence the interaction of people with their device (even mobile devices possess this characteristic).

Furthermore, the use of new mobile devices (e.g. smart glasses or watches, or shirts) forces us to think about their integration into people's daily lives, especially with regard to quality aspects as safety, privacy, intimacy, and fun. **Guaranteeing quality** attributes in this context is even more relevant due to the intensity of use.

Another challenge is related to **standards and regulations** for the communication between devices and embedded components. The development of communication protocols, interfaces and methods for easy integration is a challenge for mobile interaction design and development. Another important factor are ethical aspects that involve the intensive use of systems in daily life, such as user manipulation.

3.3 Impact on Mobile Interaction Design Methods

The challenges arising from smart ecosystems that are not just mobile-specific lead to further impacts on mobile interaction design.

Challenges in Smart Ecosystems	**Impact on Mobile Interaction Design Methods**
Complexity and size	• The complexity and the size of smart ecosystems cannot be detached. Methods should support designers and experts to identify and organise the volume of information that emerges with smart ecosystem (dominating the chaos). It has to consider the whole experience and service in which the user is participating. • Example: Breaking vast amount of information down into single tasks like when monitoring drone delivery. The user should be able to focus on essential functionality to take over the control.
Integration of heterogeneous systems	• User will still interact with real objects, not everything will work with information systems on smartphones or apps. Methods should support the development of new concepts of interaction, considering the focus of integrated sensors in daily objects as well as in the mobile devices itself. • Example: The integration of sensor for perceive the user situation

	(e.g. shirts with heart beat sensor) as well as displays integrated in common objects (e.g. smart cups) will enrich our interaction with smart ecosystem
Guarantee of quality	• Methods should support a systematic construction of quality aspects in the interaction design of mobile applications, both in the identification of context-based quality attributes as well as in the active integration of such qualities in mobile app design. • Example: The interaction design related to a drone that is part of a smart ecosystems leads to required quality guarantees e.g. even regarding safety and security.
Standards and regulations	• Methods should give clues for the integration with other smart ecosystems classes. Especially in the (short-term) development of mobile apps it is important to consider technical aspects, such integration in other smart ecosystems, in early phases of the design process. • Example: The interplay of mobile devices and devices likes drones leads to a clash of standards and regulations like regulated flight times that need to be considered by the mobile software.

Table 3: Challenges in smart ecosystems and their impacts on mobile interaction design methods

4 Coverage of Challenges by Existing Methods

To answer our research question, we need to relate the identified challenges and corresponding impacts (see Table 3) to the abilities of existing mobile interaction design methods. Table 4 presents some representative methods already used in projects by the authors and indicates the challenges faced by these methods when developing mobile apps in the context of smart ecosystems.

	Complexity and size	Integration of heterogeneous systems	Guarantee of quality	Standards and regulations
mConcAppt [6]		x	x	
mPotential [7]		x		
In Situ Design [8]		x		
A Diary Study of Mobile Information Needs [9]	x	x		
Experience Clip [10]		x	x	

Table 4: Coverage of challenges by existing methods

mConcAppt (*Conception of Mobile Apps*) is a framework that supports UX experts and developers in designing new mobile applications. The main value of mConcAppt is the systematic consideration of quality aspects in this user-centered method [6]. The framework focuses in the quickly generation of interaction concepts that support concrete task in business process. Because the mobile apps are created in the context of a concrete process, we consider that this method attend partially the integration with other systems. An improvement potential in the framework is related to the consideration of more aspects of the user context when conceiving the mobile app. Particularly the use of a technique called *product philosophy* that considers quality attributes through the conception of mobile interaction design enables the integration of adequate quality attributes in the mobile app.

mPotential supports UX and requirement experts in identifying the mobility potential of processes and roles [7]. Using mPotential, it is possible to identify in the context of an organization the roles and tasks that have the potential to be supported with a mobile app. The method allows the detailed modelling of role, task, transit time, work time outside of the main work place and special physical conditions during the execution of tasks. This leads to the derivation of improvement potential ideas in terms of mobile apps.

In Situ Design provides techniques that enable requirements elicitation and user testing in the place of use of mobile devices [8]. This technique leads to a collaborative design of mobile apps in the place that it is used with the help of representative of the target-group. The main insights increase the integration of the mobile app in the routine of the users and involve then in the design process.

This is a diary-based method for the identification of the information demand and acquisition strategies of user representatives during a medium period of time (2 weeks) [9]. Significant in this technique is the systematic annotation of the information demanded by the users in their daily routine and the origin of the information with the current technologies. Especially in the context of smart ecosystems, where a big amount of data is available, having insights on the information demand by users and the origin of this information is essential to improve the development of concrete services in smart ecosystems. Additionally, this technique helps in understanding how people handle big amount of information, e.g. breaking it down in more hierarchical levels or selecting concrete sources for the wished information.

Experience Clip allows users to record their daily interaction with the application with a focus on the emotions and the context in which people are using the mobile application [10]. Context information and emotional state are very relevant aspect, when design for mobile application. This video diary helps designers to understand the daily routine of the users of such systems, their pains and improvement potential.

As we can observe in the table above, all methods try to cover the integration of mobile app in the usage context of the user. Nevertheless, this is just one important aspect for mobile interaction design in smart ecosystem.

This fact calls for the extension of existing methods or the development of completely new ones that support the identified challenges for smart ecosystems.

5 Conclusion

We have shown that mobile-specific development affects classical interaction design through aspects such as context awareness and limited resources. We mapped the ecosystem specifics with regard to mobile interaction design, such as complexity and size as well as standards and regulations that have a significant impact on mobile interaction design.

Overall, none of the considered methods covers every challenge arising from the characteristics of smart ecosystems. However, they are partially useful (see Table 4), which means that it is necessary to tailor these methods or to create a new one in order to address all challenges with regard to smart ecosystems.

As future work, we plan to derive specific requirements according to the whole software development process in consideration with the identified peculiarities of mobile applications and smart ecosystems in order to identify further impacts on mobile interaction design. These will be used to adapt our methods mConcAppt and mPotential and even develop new approaches to take into account the trends and challenges of smart ecosystems. We also call on experts to think in these aspects and work in the development of approaches that address the challenges presented by smart ecosystems.

6 Acknowledgments

This publication is based on the research insights resulting from the Fraunhofer Innovation Cluster "Digital Commercial Vehicle Technology". This cluster is funded by the European Union, the state of Rhineland-Palatinate, and the Fraunhofer-Gesellschaft.

References

[1] Portio Research: Mobile Applications Futures 2013-2017, Analysis and Growth Forecasts for the Worldwide Mobile Applications Market, pp.22-28, 2013

[2] P. Liggesmeyer, “What does an ecosystem have to do with software?”, Fraunhofer IESE Annual Report 2014/2015, Smart Rural Areas, pp.18-19, 2015

[3] J. Knodel; C. Webel: Softwareentwicklung 2020. Business Technology Magazin (www.bt-magazin.de), BT 1.2013

[4] Chen, S. L., Wang, Yue and Tseng, M. M. 2009, "Mass Customization as a Collaborative Engineering Effort", International Journal of Collaborative Engineering, 1(2), pp. 152-167

[5] H. Muccini, A. Di Francesco, P. Esposito, "Software Testing of Mobile Applications: Challenges and Future Research Directions," 7th International Workshop on Automation of Software Test (AST), pp.29-35, 2012

[6] S. Hess, F. Kiefer, R. Carbon, "Quality by Construction Through mConcAppt: Towards Using UI-construction as Driver for High Quality Mobile App Engineering," Conference on the Quality of Information and Communications Technology (QUATIC), pp.313-318, 2012

[7] S. Adam, R. Carbon, S. Hess, F. Kiefer, G. Kutepov, N. Riegel, „Mobility Potential Analysis Method," IESE-Report 083.12/E, Kaiserslautern, 2012

[8] M. de Sa, L. Carrico, C. Duarte, "Mobile Interaction Design: Techniques for Early Stage In-Situ Design," HCI: New Developments, InTech, 2008

[9] T. Sohn, K. A. Li, W. G. Griswold, and J. D. Hollan, "A diary study of mobile information needs," In Proc. of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, pp.433-442, 2008

[10] M. Isomursu, K. Kuutti, and S. Väinämö, "Experience clip: method for user participation and evaluation of mobile concepts," In Proc. of the 8th Conf. on Participatory design (PDC 04), Vol. 1. ACM, New York, pp.83-92, 2004