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# Puzzle: A mobile application development environment using a jigsaw metaphor<sup>☆</sup>



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## ABSTRACT

*Objective:* Create a visual mobile end user development framework, named Puzzle, which allows end users without IT background to create, modify and execute applications, and provides support for interaction with smart things, phone functions and web services.

*Methods:* Design of an intuitive visual metaphor and associated interaction techniques for supporting end user development in mobile devices with iterative empirical validation.

*Results:* Our results show that the jigsaw is an intuitive metaphor for development in a mobile environment and our interaction techniques required a limited cognitive effort to use and learn the framework. Integration of different modalities and usage of smart things was relevant for users.

*Conclusion:* Puzzle has addressed the main objective. The framework further contributes to the research on mobile end user development in order to create an incentive for users to go beyond consuming content and applications to start creating their own applications.

*Practice:* Usage of a mobile end user development environment has the potential to create a shift from the conventional few-to-many distribution model of software to a many-to-many distribution model. Users will be able to create applications that fit their requirements and share their achievements with peers.

*Implications:* This study has indicated that the Puzzle visual environment has the potential to enable users to easily create applications and stimulate exploration of innovative scenarios through smartphones.

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## 1. Introduction

Hardware and software play an important role in supporting professionals, such as architects, doctors, engineers, designers, mathematicians, film directors, and many others [1]. Such professionals exploit complex and powerful

functionalities within a set of applications to achieve results for the task at hand. The development of such applications requires considerable effort, and the procedures, methods or approaches used often require adaptations to improve work practices, made necessary, for example, by new regulations or new capabilities being introduced in the applications considered.

In addition, a current technological trend is the increasing availability of smart things that can help us in different tasks. Smart things are physical objects able to interact and communicate with each other and/or with the environment to exchange data and information 'sensed' about the environment, while reacting autonomously to events in the

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'real/physical world', and influencing it by running processes that trigger actions and create services. These smart things are networked together; they are able to access Internet services, interact among themselves and with human beings. However, applications and smart things are not directly interconnected, being created by different stakeholders and using heterogeneous protocols [2].

This plethora of applications and smart things often requires application customization and interoperability. Furthermore, constant changes in our world often force people to improvise, evolve and innovate. Such demands are challenges, and users would like to address them creatively while adapting solutions to the problems at hand [3]. The complexity of the problem is further increased with people often facing these challenges on the move, outside of office environments with easy access to their smart phones. In many cases, the mobile phone is becoming the main platform that users are working with to support their daily activities. Thus, there is a need for new tools to support these demands.

One main challenge is to identify how to design application development environments able to support integration of such technologies through intuitive mobile interactive environments. The challenge is further complicated by the limitations presented in mobile platforms with limited screen sizes, usage of touch-based interaction and heterogeneous contexts of usage. The creation of such environments can explore the usage of pictorial metaphors, which are representations of real world objects that can ease the creation of mental models to make the UI intuitive. In addition, a common and agreed upon architecture to support such vision is also lacking. The architecture should be flexible and enable the framework to be interoperable and easily extendable.

This paper discusses a framework named Puzzle, which considers these trends and *enables end users without programming experience to develop or customize their mobile applications*. There are various motivations for the proposal of this framework. Professional developers lack the domain knowledge that end users cannot easily articulate when transmitting requirements for a new application, and regular development cycles are too slow to meet users' fast changing requirements [4]. End user developers outnumber professional developers, thus it is important to develop End-User Development (EUD) tools that are easy to learn and use, and to increase their quality and relevance for the users [5]. The Internet, and wide spread usage of mobile devices are potential tools to create a shift from the conventional few-to-many distribution model of software to a many-to-many distribution model. Lastly, the reason smart environments are still largely unrealized is because research is technology-centric, with inadequate focus on user needs. Thus, creating tools that allow users to develop what they want from smart environments will expand the possibilities where technology can be used to intelligently support user's tasks [6].

Puzzle can connect applications to Web services, native phone functions and existing smart things to start exploring new and innovative scenarios. Puzzle also allows users to dynamically customize their applications in an intuitive and opportunistic mode. A user-centered approach has

also been followed, with users providing feedback in some evaluation studies.

This EUD approach was previously introduced in some preliminary work related to the underlying architecture [7] and the possible metaphors and interaction techniques [8]. This paper discusses a new underlying architecture as an enabler for interacting with web services, phone functions and smart things; and the new UI of the environment as an enabler for creating complex applications through a simple process, and reports on new user studies.

The research reported on herein intends to address the following research issues:

- How end-users users can be supported to create services and applications in a touch-based mobile device?
- What technologies can be used to support heterogeneous mobile devices and smart things?
- What level of programming granularity would be suitable for the development of end-user mobile applications?

In [Section 2](#), we summarize the state of the art related to academic and industrial projects that were used as a basis and inspiration to create Puzzle. In [Section 3](#), we introduce a scenario providing an overview on how an end user would interact with the system. In [Section 4](#), we discuss the Visual Environment, metaphors and interactions techniques and how end users are able to interact with it. In [Section 5](#), the architecture is discussed to describe how we have integrated the different technologies within Puzzle. In [Section 6](#), we discuss the evaluation performed including a description of the participants and the methodology used. [Section 7](#) reports the results obtained in our evaluation and, [Section 8](#) includes a discussion of the results. Lastly, we draw some conclusions and discuss the benefits of Puzzle and future work to further improve the framework.

## 2. Related work

The development platform mainly used in EUD environments for creating mobile applications has been the desktop. The application domains considered range from support through a set of template applications for tourism [9,10], domain-related content management to support guided tours [9–11], collaboration of different stakeholders [11], up to EUD design environments using concepts such as event-based workflow rules [12]. Namoun et al. [13] introduced design recommendations for lightweight service composition environments, considering aspects such as providing guidance to users, balancing difficulty and motivation, graphical development and level of abstraction, previewing of the application, language and terminology, usage of templates, system help and aesthetics. In Puzzle, we have considered similar aspects and further tailored them in a concrete solution to be used in mobile devices. In addition, Puzzle differs from the work done in the ServFace project by Namoun et al., since the target development platform is different and the framework is able to support not only web services.

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