

A Conceptual Usability Framework for Mobile Service Consumers

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Abstract. Variation and count of mobile devices accrue each day and Service Oriented Architecture (SOA) decompose the systems into loosely coupled and platform independent software services that facilitate integration of mobile devices to enterprise systems as a service consumer or provider. The prosperity of interactive systems is relayed on the realization amount of user needs according to User Centered Design (UCD) requires the approach of how user prefers doing their tasks instead of forcing them such that the preference effecting factors are user's experience, ability and so on. Beyond the UCD user's personality could shape her/his preferences. In this paper we propose our context adaptable User Interface (UI) providing framework to enhance usability for various mobile service consumers; our framework include user personality and its dimensions, user movement speed, user role in movement, available bandwidth, memory and processing power as effecting factors in presenting appropriate UI and shifting between access modalities.

Keywords: Mobile SOA, User Centered Design, Five Factor Model of Personality, Dynamic Service Composition User Interface, Mobile User Interface.

1 Introduction

Users understand and interact with a system through its UI. The concepts, images and terminology presented in the interface must be appropriate to users needs. For example, a system that allows customers to buy their own tickets would be very different to one used professionally by ticket sales staff. The main differences are not in the requirements or even the detailed use cases, but the characteristics of the users and the environments in which the systems might operate [4]. The UI must also cater for a potentially wide range of experience along at least two dimensions, computer and domain experience; in general possessing experience causes usability emphasis on "ease of use" and lacking experience makes emphasis on "ease of learning" [4].

As Rational Unified Process (RUP) [4] mentioned UCD is used not only to have a better understanding of system requirements, but also of the users themselves, their tasks and environments. Each have their own attributes and taken together are referred to as the context of use [4]. Tasks in mobile application development are classified by [1] and two others will be scrutinized as bases of proposed framework in this paper.

Mobile devices are common these days and are produced with different platforms, programming languages support, memory, processing power, network connections and user interface facilities such as Near Field Communication (NFC), etc. by different manufacturers and are subjected to connection intermittence. SOA [14] and dynamic service composition [15] provide various integration opportunities and enriching and popularity of mobile devices make them apt for integration to other software systems; Platform and programming language independent approach of the SOA make possible the integration of various platform including fixed and mobile devices And loosely coupling achieved by SOA well matched to connection intermittence of mobile Providers and consumers. But usability of these provided services suffers from several limitations of mobile devices such as limited keypad, screen size and so on that makes desktop computers like user interfaces inefficient for them and also various factors that mentioned in abstract could affect the usability of provided UI for mobile environment especially to dynamic composed services. In this paper we overview mobile devices specific interaction techniques such as speech based [5, 7] and augmented reality [11, 12] interfaces that latter include Near Field Communication (NFC) tags [10- 13], visual markers [2, 11, 12] and so on. And with imparting user and environment spectrums and investigating appliance of UCD appropriate to mobile devices, their environments, changes of them and using psychological mapping of statistics data we propose our UI providing framework that enhance usability for mobile service consumers.

The reminder of the paper is organized as follow. In section 2 an overview of related works that include using UCD for mobile systems (regardless of SOA), variance types of mobile UI for interacting with services and access modality changes [8, 9] in mobile system is presented. Section 3 discusses UCD's users and environment possible scopes for mobile service consumers and section 4 is dedicated to proposed overall architecture. Finally, In Section 5 we sum up the paper by providing conclusions.

2 Related works

This section is dedicated to portraying three categories of related work:

- Applying UCD for mobile system development
- Applicable techniques and technologies in mobile UI interactions and its automatic implementation solutions for mobile SOAs.
- shifting between access modalities

Each category is briefly described in a separate sub-section as follow:

2.1 Applying UCD for mobile system development

In [1] the experience of applying UCD in development of two mobile applications for smart phone market is described; they performed first-hand contact with users and usability testing thru selecting a group of people as specimen; specially they determined two category of tasks i.e. dependent or independent of specific mobile context; based on this categorization they have run usability test for a navigation product that was context dependent in real environment and for integrated image or multimedia message editor product that has independence to user context in the meeting room (usability lab) environment.

2.2 Mobile UI techniques and technologies

Mobile UIs suffer from limitation on screen, keypad and selecting tools of these devices; in contrast this devices are equipped with peripheral capabilities such as camera, NFC reader, etc. that could enable them to shape user interactions in fashions that enhance the usability level of the system. The following sub-section describes mobile UI techniques and technologies.

Graphical User Interface (GUI). Simplest mobile device UIs are GUIs that are imitated from desktop computer GUIs and have the aforementioned usability obstacles.

Speech based UI. Verbal interaction of mobile users and services in most cases provide usability enhancements [5, 7] but following problem make them less prevalent [5].

- Inputs containing multi-digit numbers via verbal interfaces are more cumbersome than simple text based inputs.
- To avoid unanticipated consequences due to speech recognition errors verbal UIs must seek confirmation before taking any action on input.

Near Field Communication (NFC). NFC is a communication technology that enables mobile device to interact with tagged physical objects and other mobile devices in few centimeter distances without requiring a line of sight [10]. In [11, 12] a framework entitled PERCI is described that generate the UIs for various mobile devices to interact with NFC tags and visual markers (section 2.2.4) so that users can discover and invoke services thru interacting with physical objects.

Visual Marker. Visual markers are graphic symbols designed to be easily recognized by machines. They are traditionally used to track goods, but there is increasing interest in their application to mobile human-computer interaction (HCI). By scanning a visual marker through a camera phone, users can retrieve localized information and access mobile services. Limitation of these bookmarks is that they are not expressive to humans, and thus fail to convey information before being scanned [14]. In [2] a framework to improving human interactions with visual bookmarks is presented so users can design explicit to ambiguous visual bookmarks and marker recognition is based on the relationship of dark and light regions instead of shapes.

As mentioned in *NFC section* [11, 12] describes a framework that generates UIs with NFC tags and visual markers for mobile service consumers.

Contextual Bookmark. One important disadvantage of visual markers and NFC tags is disturbing the object's visual appearance or incurring the installation of electronic tags. In addition, the user needs certain knowledge for interaction with them [3].

A contextual bookmark is defined as a combination of a snapshot of a physical object taken with a mobile device and meta-information about the content related to this physical object [3]. The snapshot comprises context information such as time, location and also optionally can contain preferences and intentions of user. This meta-information results from context analysis (i.e. matching picture with available ones in a specific location and time) and comprises content description and links to related services.

These bookmarks are created by user as simple as taking a picture by smart device, can be exchanged with other users and provide accessing to relevant services.

2.3 shifting between access modalities

Shifting between access modalities points to change of user interaction device based on availability of them. For example, making preparatory work using a limited capability mobile device while traveling towards office, and changing to a full-scale PC application upon arrival [8]. In [9] changing access modality is achieved thru layering to application logic and UI, defining abstract UIs and generating concrete ones. Their framework provide stateless UI level migration that can transmit complete task from mobile device to desktop computer but switching ongoing tasks which requires statefull UI level migration is not in the scope of their work.

3 UCD for Mobile Service Consumers

As introduction points, UCD emphasis is on discern real people that will use system thru the first hand interaction with them; Not only to understand system requirements, but also identifying users themselves, their tasks and environments. Each have their own attributes and taken together are referred to as the context of use [4]. In RUP [4] attributes suggested for each of context of use elements quoted from ISO13407 is presented as Table 1.

Table 1. Context of use from ISO13407 Viewpoint [4].

Context	Attributes
Tasks	Goals of use of the system, frequency and duration of performance, health and safety considerations, allocation of activities, operational steps between human and technological resources. Tasks should <i>not</i> be described solely in terms of the functions or features provided by a product or system.
Users	Knowledge, skill, experience, education, training, physical attributes, habits, preferences, capabilities.
Environments	Hardware, software, materials; physical and social environments, relevant standards, technical environment, ambient environment, legislative environment, social and cultural environment

As mentioned in section 2 a categorization of tasks based on mobility content dependency is presented by [1]. The reminder of this section concentrates on users and environments elements of context of use in mobile systems and considerable points to realizing them for mobile service consumers. As will be seen main challenge for applying UCD for them is dynamic change of user's environment and enormous types of users possible by SOA that make first hand interaction troublous.

3.1 User

As mentioned in introduction the UI must be catered at least in two dimension computer experience and domain experience. In general experience lead usability effort to 'ease of use' whereas this effort concentrates on 'ease of learning' for novice users. In addition user gain experience over time that frequency of use, training, motivation, complexity and so on effects its change rate; some of these factors is quoting from [4] as Table 2.

Table 2. Some factors affecting user-interface design [4].

	<i>Low</i>	<i>High</i>
<i>Computer experience</i>	Simple question and answer, simple form-fill, web (hyper linked) or menu interface style	Complex form-fill, web (hyper linked) or menu interface style (question and answer or simple form-fill would be very frustrating to experienced users)
<i>Domain experience</i>	Common terminology and concepts	Domain-specific terminology and concepts
<i>Training</i>	Focus on ease of learning (consistent, predictable, memorable)	Focus on ease of use (direct, customizable, non-intrusive)
<i>Frequency of use</i>	Easy to learn and remember, simple interface style	Easy to use, multiple shortcuts and techniques to allow user control
<i>Motivation</i>	Rewarding to use, powerful without seeming complex.	Sophisticated with many advanced and customizable features.

From the learning perspective mobile service consumers are dividable to enterprise and nonenterprise users; enterprise users commonly have high frequency of use, high motivation and significant domain knowledge therefore 'ease of use' is valuable for their UIs; on the other hand these users spend significant time in organization that makes switching between access modalities from mobile device to desktop computer and vice versa a factor of ease of use to improve usability for them.

In contrast, nonenterprise users have broad variance that range from experienced to novice with different frequency of use; but the commonality of nonenterprise users is hardship or even impossibility of direct training for these

users; therefore 'ease of learning' is essential characteristic of their UIs; machine- and human- readable visual bookmarks [2] and conceptual bookmarks [3] are among applicable technique for 'ease of learning' to mobile consumers. In spite of the barriers for training to improve nonenterprise users capabilities the logs of successful interactions of user make reveal needs for changing focus to 'ease of use'; in the same way [7] exploits these logs for verbal UIs. Further psychological analysis on mobile device pattern of use can reveal personality dimensions of users and vice versa [16, 17]. Also the acceptable frequency of use can shape the persuasive systems design [18] opportunity to improve user behaviors and attitude changes.

3.2 Environment

Mobile user interacting environment can be compartmentalized into internal and external environments; internal environment refers to user's mobile device that its facilities such as NFC reader, network interfaces (GPRS, WiFi, Bluetooth, etc), processing power, available memory and so on shape or constraint possibility of each interaction method. For instance [5] presented a voice along with text interface for invoking web services to enhance usability level that obviously require more available processing power and memory size than text or voice only interfaces (in our framework which of this three is best for specific user with specific device in specific external environment is determinable- section 4). Almost internal environment is permanent for each user and commonly its change is shifting between access modalities that occur while user mobility state alter between stay and roaming so that her/his interacting device can change from mobile device to PC or vice versa. External environment is user's surround environment that its facilities such as augmented posters and its properties including noises, available bandwidth of possible networks, stay or movement, movement speed, user role in movement (passengers, driver, walking, running and so on) with existence of complementary facility in internal environment (mobile device) determine presentable UIs.

Therefore internal and external environment determine the range of possible UIs in each time interval; user type (enterprise, non enterprise) and her/his experience with system narrow environment scope of selections.

This is well worth heeding that the categorization of tasks based on mobility context dependency offered by [1] is not equivalent with categorizing to dependent and independent of external environment; because in spite of the location independence common factors other factors, which are independent from mobility context, such as noise are part of external environment and can influence UI selections.

4 Proposed Architecture

As reviewed in section 2 available frameworks mainly concentrate on specific UI types (voice [7], voice and text fix combination [5], augmented reality [11, 12], conceptual bookmarks [3] and so on); also section 3 points that UI design is influenced by tasks, users and environments that briefly discussed. Analogous to [6] that studied context-aware mobile SOA dynamically and categorized applications into four levels of requirement, from the non-dynamic (i.e. static) level in which the contexts of clients, intermediate media, and services were all static, to the highly dynamic level in which all aspects were dynamic [6] and based on this they proposed their framework that facilitates mobile SOAs we determined users and environments context of use attributes for mobile service consumers in prior section and this section is concentrated on proposing an architecture to facilitate mobile SOAs usability.

The architecture is shown in Fig.1 and the functions and requirements for each component and their interdependencies are described as follows.

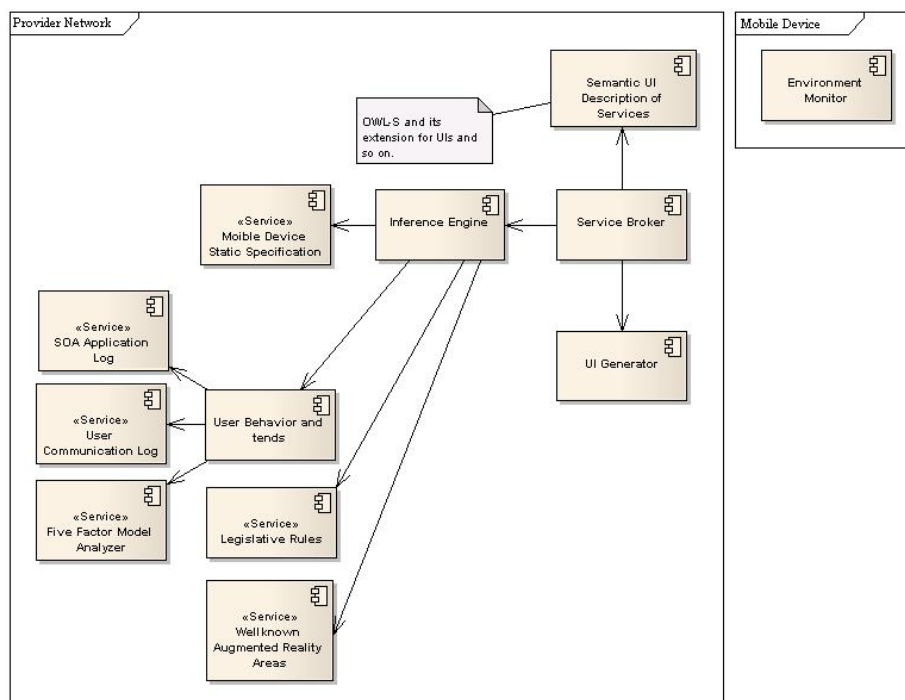


Fig. 1. Usability framework for mobile Service Consumer's architecture.

In our architecture the *Environment Monitor* Component is deployed on mobile device and all reminder components deploy (and optionally distribute) in fixed nodes of service provider network with the exception of *user communication log* service that can be managed by mobile operator network instead of service provider.

Environment Monitor component provides state information of internal environment such as available memory size, processor load and also state information of external environment such as available networks (GPRS, WiFi, Bluetooth, etc) and bandwidth of each one and composite data such as allocable bandwidth to interaction (some channels may be used by other application and is not available for this one); this state information will be sent to provider along with service request. This component also send environment noise information and user speed so former is gathered based on mobile device microphone's received frequencies and user speed gains from GPS (although it can be externally gained in provider network with some accessibility). Upon receiving service request *Service Broker* discovers the appropriate service (service discovery itself is not part of our proposed framework in Fig. 1. and will be as default) and sends UserID, state information and mobile device type to *Interface Engine* component and in response it receives description of appropriate UI for interaction of mobile user with service; *Interface Engine* proposed UI can be a fixed type such as oral or multiple complete fixed type e.g. voice and text full fledged UI or even composite UI such as receiving available parameter via NFC and others by voice and text. Based on discovered service description and proposed UI type *Service Broker* interacts with *Semantic UI Description for Services* component and gains extended semantic description of service (e.g. an extension of Semantic Markup for Web Services (OWL-S) is used in [11, 12] for NFC tags and visual markers) and sends it to *UI Generator* component; this component prepare targeted UI and directly sends it for the user as response of her/his service request.

Determination of appropriate UI by *Inference Engine* includes eliciting mobile device specifications (internal environment) and user's preferences-specifications thru interacting with *Mobile Device Static Specification* service

and *User behaviors and tends* service respectively; further *User behaviors and tends* service is composed of *SOA application log* (applications logs of user), *user communication log* and *Five Factor Model Analyzer* services that latter infers user personality facets based on Five Factor Model [19]. The Five Factor Model dominates the current view of personality and provides a unifying structure to its study; this model has, in fact, garnered so much support that the FFM “has now become an almost universal template for understanding the structure of personality” [20]. The five dimensions of the Five Factor Model of personality are neuroticism (or emotional stability), extraversion, openness to experience, agreeableness, and conscientiousness [20]. authors of [16, 17] investigated mobile device pattern of use (calling, SMS, changing ring tone and so on) based FFM facets and [21] apply FFM to investigating information system continuance intention that both can reside in *Five Factor Model Analyzer* service logic.

User behaviors and tends service also contains user’s attribute mentioned in Table 1 for enterprise users so that provide behavior and tend of user based on FFM analysis and this attributes; obviously, latter is not applicable for nonenterprise users. It also computes some Table 1 attributes such as user’s experience improvement ratio (a simple ratio) for all users.

if user speed, that is sent by her/his request via *environment monitor* component, indicate that user is walking *Interface Engine* also enquiry *Well known Augmented Reality Areas* service for availability of augmented reality interface possibilities i.e. NFC tags and visual markers in external environment. In addition as mentioned in table 1 (quoted from [4]) and its section 3 descriptions legislative environment such as calling restriction on driving is part of external environment and restrain UIs choices for the user. *Inference Engine* resides combination rules for aforementioned services and *Legislative Environment* service provide legislative environment rules, as an example if user speed is more than walking it can be an Inference Engine rule that augmented reality interface cannot have external environment support and there is no need to interacting with *Well known Augmented Reality Areas* service and another rule suggest high extraversion level persons prefer voice interactions over text so oral UI has a good chance, in this situation if user state is deriving the mentioned legislative environment rule prohibit verbal interactions and inference engine choice would be limited to GUI until user change her/his state that can be detect in her/his subsequent requests and gaining user confirming to change to new possibilities.

Since rendering UI, user invokes the service by filling service parameter via offered methods based on her/his interaction logs, preferences and internal and external environment constraints. As mentioned *SOA Application Log* service is the repository of interface interactions of user it can directly updates based on single option UIs such as voice only, GUI, conceptual bookmark and so on however in multiple options UIs, e.g. voice along with text interfaces, user interaction scenario is unknown so there is a need to client sent its logs, to avoid user perceived delays environment monitor component send this logs when the connection is up but idle [22]; for keep simple this sequence is not illustrated is fig. 1.

Shifting access modality from mobile device to PC consist of sending IP address of targeted PC (optionally from user settings) and current state of UI i.e. its user provided inputs, to provider and regenerating UI in the same way that portrayed with leaving out interacts by Well-known Augmented Reality Areas and Mobile Device Static Specification services. However inverse access modality change i.e. from PC to mobile device suffers from lacking state information of mobile device and in our framework cannot be shaped automatically and it require saving UI state on provider and sending resume request from mobile device.

5 Conclusion and future works

In this paper we investigated various mobile service consumer UI possibilities to fulfill usability factors of UCD for classifying the usability problem complexity of them. We further represented our overall usability framework that it employs Five Factor Model of personality in selecting appropriate UIs and considers user speed, user role in movement, available bandwidth, memory and processing power and supports statefull shifting between access

modalities as its novelty. In this paper we concentrated on usability of mobile service consumers but obviously concrete mobile SOAs require composing our framework with architectural tactics that support other quality attributes such as caching and prefetching [22- 26] for availability and performance supports. We plan to enrich our framework by location prediction patterns [25, 27] and abstracting its improvements.

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