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Context awareness: Challenges and opportunities in modern smartphone use

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Abstract: Commonly, improvement to smart-phone technology focuses at advancing the connectivity of human users. This results to better and richer information access but, undeniably, it also increases the accessibility of the users themselves, something that could arguably have negative side-effects. This position paper discusses the potential of context awareness in modern smart-phones by presenting the challenges and opportunities in modern smartphone use. In particular, we examine the implications of the advanced network capabilities-and accompanying services-of modern smart-phones and list what we argue to be their main drawbacks. We then present our position which summarizes what we expect the role of context-awareness to be in modern smart-phone applications.

Keywords: Context, Context-awareness, Challenges, Opportunities, Smartphones

1 Introduction

In recent years, we have experienced the rapid growth and evolution of the mobile phone market. With more than 4.1 billion subscribers-and with the global population penetration exceeding 61%-as of 2008, mobile phones have been named the most prolific technology ever [Rub08]. Meanwhile, an increasing fraction of the mobile phones are branded as smart-phones, vaguely meaning that they feature sophisticated (third-party) applications. Evidently, the industry took note of the trend and they have introduced a number of highly capable platforms, most notably the iPhone, BlackBerry and Android-while the competition is only getting more intense with alliances such as the one by Nokia and Microsoft which was recently announced [But11] [Wan10]. Packing the functionality of devices such as the personal computer, personal digital assistant, digital camera, music player, navigation system, and-of course-the mobile phone, it is no wonder that smart-phones are considered one of the top technologies of the decade [Rom11]. Especially since the formation and development of application ecosystems [MS04], smart-phones have endeavoured at becoming an indispensable part of our everyday lives, both in terms of lifestyle and utility. However, it can be argued that while the smart-phone has tremendously increased the potential of its users for communication and interaction, it has also introduced some-arguably negative-side-effects. In this position paper we argue that context aware applications can be the key to overcoming them. The rest of this paper is organized as follows: Section 2 discusses the evolution of context awareness as well as the capability of modern smart phones for context aware behaviour. Section 3 discusses a few critical challenges for the future of mobile phone use and argues how these open up opportunities for developing novel context aware applications. The paper closes with conclusions in section 4.

2 Context awareness and smart-phones

Context-aware computing has been actively studied since at least mid-nineties [SAW94], shortly after Weiser introduced the concept of Ubiquitous Computing [Wei91]. Initially, research was concentrated on stand-alone context-aware applications, mainly location-aware ones (e.g. tour guides and active badges [LKAA96, Pas97]). However, as the interest for context awareness picked up, the research naturally shifted towards building frameworks providing support for general context-awareness, such as the Context Toolkit, CARISMA and MUSIC [DAS01, CEM03, PRB+08]. However, only recently have powerful smart-phones been introduced, featuring many sensors and capabilities, paving the way for sophisticated context-aware applications. Although context awareness has been studied for nearly two decades now, no widespread adoption of context-aware applications can be claimed yet. While a few commercial applications feature context-aware behaviour already, these are primarily limited to location awareness, and their context aware behaviour is often a (not critical) subset of the application logic. It can be argued that *the killer-app of context-awareness has not been invented yet*.

2.1 Sensing context

Sensors are common in most modern smart phones now. These include both hardware-based and software-based sensors. The most typical hardware sensors include: GPS sensor (used for follow-me applications, positioning, navigation, etc); WiFi/GSM sensor (signal strength and base station id-can be used to infer location); Accelerometer sensor (used to infer user status-walking, running, driving, etc); Orientation sensor (UI modality-adjusting the way the UI is presented to the user); Compass sensor (direction-allowing for sophisticated navigation applications); Light sensor (ambient lighting conditions-e.g. in tunnel while driving); Camera (tags-e.g., infer location with QR codes, or bridging the physical and the virtual worlds, a major application of ubiquitous computing); NFC (also used to bridge the physical with the virtual worlds).

One level above the hardware sensors we find software APIs that expose context-related information or functionality that can be exploited by mobile applications. The context information is usually derived from the underlying hardware sensors. For example Google Latitude and Facebook Check-in offer APIs to access information related to the current location of the user and people in their social network, the location history, places and things of interest and user status. The calendar is another purely software based source of context. Specifically, an application may derive from a user's calendar information regarding the user's availability and the type of engagement (work or private).

2.2 Context aware applications

Research-oriented context-aware applications appeared as early as in mid nineties. The Cyberguide [LKAA96] and the Stick-e framework [Pas97], for instance, were intelligent tour guides using location to automate their operation. Another common showcase of context awareness was with follow-me apps, such as the Intercom project [KON+00]. One of the most elaborate applications of the time was the conference assistant, which realized a scenario with an automated service meant to support attendees at an academic conference [DAS01].

A more recent application from PARC-the founders of ubiquitous computing-is the Magitti application. The authors of [Ba08] argue that applications will be increasingly intent-aware, anticipating the users' intentions. Therefore, they argue that "the system will be aware of four levels of system awareness: basic context awareness, behavior awareness, activity awareness, and intend awareness". This is also supported by Wright, who argues that applications like the Magitti will become more common [Wri09]. Finally, an extensive demo was organized by the MUSIC consortium to illustrate the viability of context aware applications, particularly as assistants to passengers and personnel of the Paris metro (an extensive coverage was also documented by euronews[1]). This demo included specialized applications such as metro navigators and assistants for persons with motor disabilities, as well as social applications such as InstantSocial which facilitates rapid interaction with nearby passengers [FHS08]. Commercial applications that are currently exploiting context information fall almost entirely under the Location Based Services category. It is becoming increasingly evident that a user's location and location history is considered a great commercial asset that can be exploited in a number of ways. Hence there is a growing interest from both application developers and network providers to build into their applications the acquisition and exploitation of that information. These applications exploit the location information to enhance the social networking experience and/or improve the relevance of information provided to the user. Among the most popular applications exploiting location information are the Google Latitude, Facebook Check-in, Twitter, Foursquare and Gowalla which provide features such as tracking the location of the user and their friends, posting and searching for user experiences at specific businesses, receiving location targeted promotional offers and geo-searching for specific businesses/points of interests in an area.

3 Challenges and opportunities in modern smart phone use

While many research and commercial applications have been developed featuring context aware behaviour, it can be argued that the killer app of context awareness has not been invented yet. By definition, a killer app is one that is so successful that it paves the way for a new family of applications (in our case, context-aware applications). Naturally, it is not only hard to produce such applications, but it is also hard to make a prediction of. We argue that while most context aware applications aim at utilizing the additional information for providing more and richer information to the users, context could also be used for exactly the opposite goal: trimming unnecessary-or lower priority-information. This is further analyzed in the following two subsections.

3.1 Challenges in modern smart phone use

Undeniably, the smart phone has changed the way hundreds of millions of people live and organize their lives by. While the smart-phone revolution has tremendously increased the possibility for communication and interaction, it has also contributed to two negative side-effects: *Information overload*: As people are constantly moving towards a faster and more hectic lifestyle, they are continuously asked to deal with an increasing amount of information. This information includes voice calls, text messages, email, as well as other data generated by browsing web-

[1] http://www.euronews.net/2010/06/16/music-to-you-mobile-s-ears

sites (such as news, sports and social network updates). At the same time, while mobile phones have increased the possibilities for communication, they have also inadvertently limited people's privacy and isolation. The physical boundaries of distance and inaccessibility have mostly disappeared, exposing us to increased and often undesired (or untimely) communication. *Frequent interruptions*: Modern office and home lifestyle experience has shown that people tend to interact with a large number of information sources, often after they are asynchronously interrupted (such as by phone calls, text messages, Twits, Facebook status updates, etc). While it has long been understood that you are less productive when you are constantly switching your attention, scholars have found something even stronger: Pioneering researchers from the Stanford's Communication between Humans and Interactive Media (CHIMe) lab have found that the impact of electronic multitasking goes beyond the momentary sense of distraction, as it can also create permanent changes to the way the brain functions [ONW09].

These observations are not new. As early as almost a decade ago, Sousa et al argued that "the most precious resource in a computer system is no longer its processor, memory, etc, but rather a resource that is not subject to Moore's law: User Attention" [SG02]. While this still holds true, only now is smart phone becoming so powerful and central to our life that we can actually respond to it. Our position is that the challenges imposed by the use of smart phones in modern life are so important that they actually provide a significant opportunity for novel context aware solutions. Naturally, information overload-especially when involving asynchronous communication such as email, text messages and phone calls-cannot be filtered manually by users. Rather, it is expected that smart phones-and their software-will be able to make such filtering for the users themselves. Furthermore, frequent interruptions of the users could easily distract them and lower their productivity. Today, the smart phone is often the main gateway of information for many people. This makes it the ideal platform for deploying software that manages communications, filtering them by priority, and perhaps grouping them in meaningful batches which are delegated to the users only periodically, allowing them sufficient distraction-free intervals.

3.2 Opportunities for context awareness in smartphones

Based on the previous observations, we attempt to define the killer app of context awareness. The key to this application is the use of contextual information to intelligently manage the communications of the user. It aims at enhancing the communication experience of the user through the exploitation of sensed context information, while preventing the user from becoming overloaded. The behaviour of the application is controlled by a number of user-defined rules that are applied using the information collected at real time by sensors such as the GPS receiver, calendar, Facebook status etc. From a functional perspective, the main opportunities that arise from the exploitation of context information in managing the users' communications are:

Minimize the amount of information communicated to the user: This extends the filtering concept that is commonly found in email applications to other forms of communications such as text messaging, chatting and voice communication. For instance, applications can be configured so that e-banking SMS messages are filtered in order to ignore informational messages (e.g., daily updates on your account balance), while allowing alert messages (e.g., about suspicious credit card activity). This is enabled by using context data such as calendar status (free, in a meeting, out of office) to activate the filtering of incoming communication.

Defer communication: For example, many smartphone users are tempted to casually read their work email even after normal business hours, resulting to them not being able to relax and rest. On the other hand, a busy professional does not want to be distracted during work hours by non-critical personal communication. Context aware apps can allow for clever filtering of the user's communication using such context information such as location, time-of-day, holiday schedule, etc. For instance, email and SMS messages arriving after business hours from co-workers are hidden until the next business day, or until the user's location changes back to work (i.e., meaning that the user is back to work and ready to resume office work). This can also be applied to voice calls being directed to a voicemail server. In this way, a virtual, protective boundary is formed between the users' personal and professional lives.

Smart scheduling: One of the most important opportunities is the ability of smartphones to schedule the users' daily activities in a way that minimizes the number of interruptions during the day and makes the information available to the user at the right time. For instance, instead of notifying the user of new status updates (e.g., from Facebook) as they happen, those are either cumulatively reported at the end of the day, or they are deferred until an actual communication occurs. For example, when Joe Smith calls, his latest Facebook status can also be shown on the smart-phone display, thus allowing the user to be intelligently updated of any useful information concerning Joe, while also minimizing the need (or urge) to periodically check friends' status.

We believe that these novel features are so important that they will trigger a new family of context-aware apps, aiming at addressing the users' need for more intelligent communication.

4 Conclusions

This paper presents our position which can be summarized in two points: First, current smart phones are powerful enough and feature sufficient sensing capacity which makes them the ideal platform for deploying context aware applications. Second, while most mobile phone applications aim at increasing the amount of information accessible by-and inevitable flowing towards-the user, we argue that there is a great opportunity for applications that aim at controlling this flow by intelligently filtering and scheduling the information delivered to the users. While it is practically impossible to predict which will be the killer app of context awareness, we foresee this as the opportunity of context awareness becoming mainstream.

Bibliography

[Ba08] V. Bellotti, et al. Activity-based serendipitous recommendations with the Magitti mobile leisure guide. *26th Annual SIGCHI Conference on Human Factors in Computing Systems*, pp. 1157–1166, 2008.

[But11] M. Butler. Android: Changing the Mobile Landscape. *IEEE Pervasive Computing* 10:4–7, 2011.

[CEM03] L. Capra, W. Emmerich, C. Mascolo. CARISMA: Context-Aware Reflective mIddleware System for Mobile Applications. *IEEE Transactions on Software Engineering* 29:929–945, 2003.

[DAS01] A. K. Dey, G. D. Abowd, D. Salber. A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human-Computer Interaction* 16(2):97–166, 2001.

[FHS08] L. Fragas, S. Hallsteinsen, U. Sholtz. 'InstantSocial' - Implementing a Distributed Mobile Multi-user Application with Adaptation Middleware. *1st International DisCoTec Workshop on Context-aware Adaptation Mechanisms for Pervasive and Ubiquitous Services*, 2008.

[KON+00] C. D. Kidd, T. O'Connell, K. Nagel, S. Patil, G. D. Abowd. Building a Better Intercom: Context-Mediated Communication within the Home. 2000.

[LKAA96] S. Long, R. Kooper, G. D. Abowd, C. G. Atkeson. Rapid prototyping of mobile context-aware applications: the cyberguide case study. *2nd Annual International Conference on Mobile Computing and Networking*, pp. 97–107, 1996.

[MS04] D. G. Messerschmitt, C. Szyperski. Marketplace Issues in Software Planning and Design. *IEEE Software*, pp. 62–70, 2004.

[ONW09] E. Ophir, C. Nass, A. D. Wagner. Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences (PNAS)* 106(37):15583–15587, 2009.

[Pas97] J. Pascoe. The stick-e note architecture: extending the interface beyond the user. *2nd International Conference on Intelligent User Interfaces*, pp. 261–264, 1997.

[PRB+08] N. Paspallis, R. Rouvoy, P. Barone, G. A. Papadopoulos, F. Eliassen, A. Mamelli. A pluggable and reconfigurable architecture for a context-aware enabling middleware system. 5331:553–570, 2008.

[Rom11] J. J. Romero. Smartphones: The Pocketable PC. *IEEE Spectrum* 9, 2011.

[Rub08] A. Rubin. The future of mobile. Sept. 2008. http://googleblog.blogspot.com/2008/09/future-of-mobile.html

[SAW94] B. N. Schilit, N. I. Adams, R. Want. Context-Aware Computing Applications. Pp. 85–90, 1994.

[SG02] J. Sousa, D. Garlan. Aura: an architectural framework for user mobility in ubiquitous computing environments. *3rd IEEE/IFIP Conference on Software Architecture: System Design, Development and Maintenance*, pp. 29–43, 2002.

[Wan10] R. Want. iPhone: Smarter Than the Average Phone. *IEEE Pervasive Computing* 9:6–9, 2010.

[Wei91] M. Weiser. The computer for the 21st century. *Scientific American*, 1991.

[Wri09] A. Wright. Get smart. *Communications of the ACM* 52(1):15–16, 2009.