On the Benefit of Adding User Preferences to Notification Delivery

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Abstract
Notifications may have a disruptive effect on users and the vision of a smart notification delivery is still an open question. Alternatively to existing user-opaque solutions, we identify the lack of significant end-user personalization features as one of the main issues in the "traditional" notification management. In this paper, we explore a preference-based approach towards smart notification delivery. By considering existing in-the-wild studies that directly involve users, we defined a set of preferences to customize the notification delivery, and we built a mobile application for their set up. We evaluated the understandability of such preferences, and the acceptance of our preference-based approach in a user study with 10 participants. Preliminary results show that the preferences were easily understood, and that users are willing to set them up.

Author Keywords
Notifications; End-User Personalization; Mobile Devices

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g.,HCI)]: Miscellaneous

Introduction and Motivations
The disruptive effect that the continuous interruptions of notifications cause to the users has already been demon-

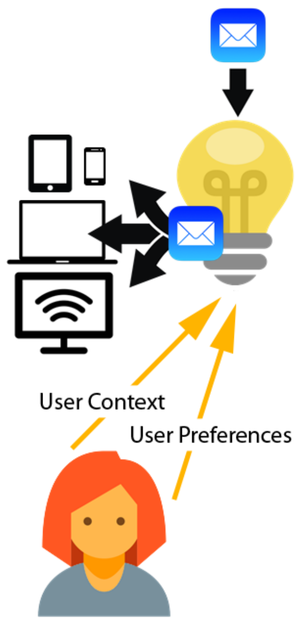

Figure 1: Our idea of a smart preference-based notification system: the end-user is directly involved in the customization of the notification delivery.

strated in the literature (e.g., [4, 1, 3]). While receiving more messages and social network updates make users feel more connected with others, an increasing number of notifications is associated with an increase in negative emotions [18]. Moreover, the number of smart objects in the contemporary Internet of Things (IoT) perspective increases every day, ranging from smartphones to smart appliances, like thermostats and fridges. In this context, notifications are widely adopted, thus highlighting even more the need of smartly managing the notification delivery [21].

At the best of our knowledge, the vision of a smart notification delivery does not seem completely reached by any previous work. The prevailing trend in this field is to analyze large data sets of data to train machine learning algorithms, without directly involving users in customizing the notification delivery. Contrary to such an approach, which produces completely opaque solutions to the users, we identify the lack of significant end-user personalization features as one of the main issues in the "traditional" notification management. In this paper, we started to explore a different approach towards a smart notification delivery, i.e., a *preference-based* mechanism that allow end-users to customize the management and delivery of their notifications. The general architecture of the approach is shown in Figure 1. An intelligent notification system exploits the preferences of the user and her current context to smartly deliver notifications on one or more user devices. The following scenario better explains our idea:

Lucy, an architect, is in her office. In this place, there are four devices connected to the Internet: three Lucy's personal devices (a smartphone, a tablet, and a laptop), and a smart TV, which Lucy uses during her breaks or for meetings. When Lucy is working on her PC, as now, she prefers to avoid distractions. In this situation, she is upset when new notifications force her to look away from the PC. In particular, she would prefer not to receive any not-important notifications (e.g., a chat message from a friend, or an advertisement notification). However, she shares a chat-messaging group with her sons, and she considers such messages as very important: she would like to receive them instantly. Lucy has already started to use a smart notification system that is customizable through her preferences. When her friend Mark sends her the usual (and boring) daily message, the system keeps the notification pending. Instead, when her son John sends her a chat message, the system immediately display it on the PC screen. After a while, when Lucy turns the PC off and starts to watch the TV, the system shows the Mark's message on the TV screen.

By communicating her preferences to a smart notification system, *Lucy* avoided distraction from notifications she hates. Furthermore, she received important notifications instantly, in a way compliant with her current activities. *Lucy* is very happy because she has all her messages under control. Furthermore, she can update her preferences in any moment. To take a step towards realizing the system used by *Lucy*, we focus on the definition and the evaluation of a set of user preferences to customize the notification delivery, along with a possible way to create them. We firstly conducted a literature analysis by focusing on how users perceive notifications. Thanks to the analysis, we defined three main categories of preferences for end-users. Then, we built a mobile application for allowing users to set up their notification preferences, and we carried out a user study with 10 participants. We were interested in assessing the acceptance of our preference-based approach, along with evaluating the understandability of the preferences we defined. Results show that the preferences provide a good match for the mental model of users. Furthermore, users appreciate the proposed approach, and most of them are willing to set up their preferences in daily life.

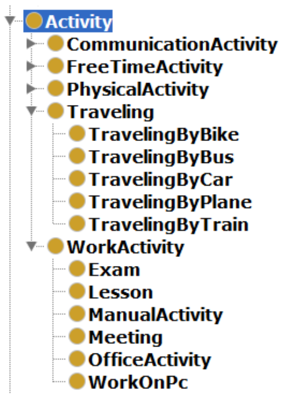

Figure 2: A partial view of the activities that can be linked to the user preferences.

Background and Related Work

As already reported in the Introduction, the problem of overwhelming notifications has been analyzed in numerous studies, which mainly analyze how notifications influence users engaged in their tasks (e.g., [1, 5, 2]). More recently, with a large-scale assessment of mobile notifications, Pielot et al. [18] report the disadvantages brought by the increasing number of notifications, such as stress and feeling overwhelmed.

Although the literature clearly shows the need of smartly delivering notifications, such vision is still an open question. Given the complexity of creating systems to smartly interrupt users, the focus of many previous works is on understanding how to compute accurate costs of interruption, and on reasoning about appropriate moments for interrupting users engaged in tasks and activities (e.g., [8, 10, 9]). Other recent existing works propose strategies to improve the user experience with notifications, like reducing interruptions, deferring notifications until the right time, and communicating (un)availability of users [18]. For example, Pejovic and Musolesi [17] propose the design of an intelligent interruption mechanism, based on a machine learning classifier, to show notifications to the user at the right moment. Furthermore, Okoshi et al. [15] propose a middleware, named Attelia, to detects good breakpoints to deliver notifications. In a subsequent work, the authors extend their middleware to Attelia II, one of the few systems that considers multi-device environments [16]. Finally, other studies try to identify suitable moments to deliver notifications. For example, Fisher et al. [6] states that the end of episodes of mobile interaction, like phone calls or text messages, are a good moment to deliver notifications, while Pielot et al. [19] consider the data deriving from smartphones usage to analyze user attention.

Despite the large literature about notifications management, existing works mainly propose solutions that are completely opaque to the users (e.g., by using machine learning techniques). We follow another approach towards a smart notification delivery, i.e., allowing users to directly define their notification preferences. At the best of our knowledge, such an approach has not yet been explored.

User Preferences for the Notification Delivery

To define a set of user-preferences for customizing the notification delivery, we conducted a literature analysis by considering large in-the-wild studies. The main finding that emerged from the analysis was that the user interruptibility highly depends on the current task [12, 13]. Thus, we first defined a hierarchy of user activity to be linked with the user preferences (e.g., *"if I am in a work meeting, my notification preferences are..."*). Figure 2 shows a partial view of the hierarchy. Then, we derived **three main categories** of notification preferences, which are summarized in Table 1 and described in the remainder of this section.

Thinking of a multi-device environment, we were interested in allowing users to customize a) *Target Devices (TD)*, b) *Notification Modalities (NM)*, and c) *Delivery Moments (DM)*. Preferences are supposed to be relative to a specific activity, a set of activities (e.g., for all the work-related activities), or, more generically, for all the activities. In this way, preferences dynamically adapt to the user context and can be defined in advance by users, without the need of continuously interacting with the smart notification system that exploits them. We built an ontology[1] to allow the def-

[1]The ontology is available at http://elite.polito.it/ontologies/awarenotifications.owl

Preference	**Delivery Aspect**
Accessibility Level	TD & NM
Type Priority	DM
Social Priority	DM

Table 1: The preferences for the notification delivery customization. They allow to influence three Delivery Aspects: Target Devices (TD), Notification Modalities (NM), and Delivery Moments (DM).

inition of the user preferences and their link with the user activities.

Accessibility Level. Two real-world studies about notifications [12, 13] show that the user activity may influence the acceptability of notifications. Furthermore, the notification modality significantly influences the time needed by the user to see notifications [13]. We summarized such findings in a first preference category, i.e., the *Accessibility Level*. The preference allow to specify how a user is able to interact with her devices during activities of a certain type, thus influencing the Notification Modalities (NM), and the Target Devices (TD). For each activity type, the *Accessibility Level* can be a combination of the following values:

- *Sight.* When I am doing these activities, I can read notifications on nearby displays.
- *Hearing.* When I am doing these activities, I can receive audio notifications.
- *Hands.* When I am doing these activities, I can directly interact with my devices to receive notifications (e.g., take the smartphone from the pocket).

Type Priority. Not all the notifications have the same importance for the user [7, 11, 20]. In particular, the importance of a notification is correlated with the application source that generates the message [20]. By considering these findings, we defined the second preference category, i.e., the *Type Priority*, that relates to the notification type (e.g., instant messages, social updates, advertisements, etc.). The preference allows users to customize the Delivery Moment (DM) of a certain type of notifications. We included in this preference the notion of *"natural breakpoint"* [14], i.e., the boundary between two adjacent units of a user's activity, in which the acceptability of notifications increases [9]. In particular, the preference is composed of three mutually-exclusive values:

- *High Priority.* When I am doing these activities, I want to receive notifications of this type immediately, in the most intrusive way.
- *Medium Priority.* When I am doing these activities, I would like to receive notifications of this type instantly, but only if my other preferences (i.e., Accessibility Level and Type Priority) are respected.
- *Low Priority.* I do not want to receive notifications of this type when I am doing these activities. At least, I would like to finish what I am doing before being notified.

Social Priority. Sahami et al. [20] demonstrate that important notifications are about people: notifications from apps that can be used for communication with others are rated significantly more important than notifications from all other categories. Furthermore, the study of Mehrotra et al. [13] demonstrate that the type of the sender has a significant impact on the notification acceptability. Thus, we defined the third preference category, i.e., the *Social Priority*, that relates to the notification sender typology (e.g., family, friends, work colleagues). This preference allow users to customize the Delivery Moment (DM) of notifications of a certain sender. It is composed of two mutually-exclusive values:

- *Important Sender.* When I am doing these activities, I would like to receive notifications from such senders instantly, but only if my other preferences are respected.
- *Not Important Sender.* I do not want to receive notifications from such senders when I am doing these activities. At least, I would like to finish what I am doing before being notified.

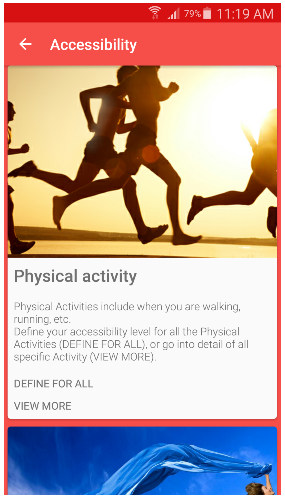

Figure 3: Selecting an activity for the Accessibility Level preference.

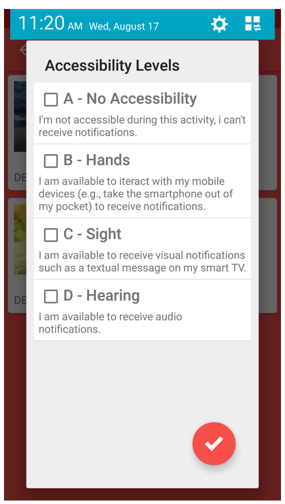

Figure 4: Selecting the Accessibility Level values.

Preferences at Run-Time

Working Examples

The defined user-preferences are supposed to be inserted, deleted, and updated at any time by users. Furthermore, the preferences can be combined to obtain more complex behaviors. For example, during work meetings, a user might not be interested in private Instant Messages (*Low Priority*), but in e-mails from her colleagues (*Medium Priority*). Furthermore, the user could prefer to view such notifications directly on her smartwatch (*Sight Accessibility Level*). However, if the meeting is boring, the user can simply update her preferences, e.g., by giving a *Medium Priority* to private Instant Messages, too. To summarize, *Lucy*, the girl of the scenario that inspired our idea (reported in the Introduction), used the following preferences to customize the delivery of her notifications:

- if my activity is of type “Working on PC”, my accessibility level is “Sight”;
- if my activity is of type “Watching the TV”, my accessibility level is “Sight” and “Hands”;
- notifications of type “Instant Messaging” have “Low priority” for all the activities;
- “Friends” are a “Not important” contact when I am “Working on PC”;
- “Familiars” are an “Important” contact for all the activities.

Preferences Composition

We developed a mobile application (Figure 3 and 4) that allows users to easily interact with their own notification preferences. In particular, by exploiting the ontology we built, such an application allows users to insert, update, delete, and view such preferences. In the composition process, thanks to three sequential menus, the application guides users to select: a) the preference category b) the activity (or the set of activities) to be linked with the preference (Figure 3), and c) the preference values (Figure 4).

Preliminary Evaluation

We preliminarily evaluated the preference-based approach towards smart notification delivery by assessing both its acceptance and the understandability of the defined user-preferences. We carried out an in-lab study where 10 participants tried to compose their preferences through the application. The participants (5 female, mean age 24.7 years, $SD = 4.57$) were recruited thanks to a mailing list of students of our university. Before the test, we introduced them to the definable preferences with a short video presentation.

Study Design

We followed a within-subject design. The test was a trial of four different tasks to be completed by all the participants. A task included a real-world scenario which described a generic user: owned devices, usually performed activities, typically received notifications, etc. An example of a scenario was:

John is a programmer. Usually, he works from home. He owns a PC, that he uses for his work projects. Furthermore, he owns two personal devices: a smartphone and a tablet. John receives a lot of messages and calls from his friends, because he is a very sociable guy. In this period, John has a lot of work. Typically, after a session on his PC, he takes a break by playing with his tablet.

Participants had to impersonate the user of the scenario. Without a predefined goal, they were free to insert the preferences at their will in the mobile application. Then, after the composition phase, we described to the participants the delivery of a specific notification related to the scenario. In the case of *John*, such a notification was explained with the following statements:

John is at home, working on his PC. He has forgotten his smartphone in another room, in vibration mode. John's tablet is turned on, in silent mode, on the desk. When John is working, a friend sends him a WhatsApp message. After a while, John takes a break playing with his tables.

Participants had to predict the delivery of the notification on the basis of the preferences they inserted in the composition phase. They had to indicate, on a paper-questionnaire, Target Devices (TD), Notification Modalities (NM), and Delivery Moments (DM). The right answers were provided to the participants at the end of the test. We concluded the user study with a final questionnaire with four questions based on a Likert-scale from 1 (Very bad) to 5 (Excellent). The questions investigated the mobile application intuitiveness and usability, the acceptability of the preferences-based approach, and the usage of such preferences in their daily life.

Results and Discussion

To assess the understandability of the user-defined preferences, we assigned three correctness prediction-value (for TD, NM, and DM) to all tasks completed by a users by analyzing the inserted preferences and the context described by the scenarios. The correctness value was the percentage of correct answers, normalized from 0 (totally wrong prediction) to 1 (completely correct prediction). We obtained the following results:

- **TD Prediction:** the correctness average for Target Devices was 0.81 ($SD = 0.30$).
- **NM Prediction:** the correctness average of Notification Modalities was 0.90 ($SD = 0.21$).
- **DM Prediction:** the correctness average of Delivering Moments was 0.90 ($SD = 0.29$).
- **Total Prediction:** the overall correctness average was 0.87 ($SD = 0.27$).

Ratings of the final questionnaires were high for each questions. The application was considered intuitive ($M = 4$, $SD = 0.67$), and with a good usability ($M = 4.20$, $SD = 0.79$). The participants considered as absolutely acceptable the time spent to insert their preferences ($M = 4.40$, $SD = 0.84$), and they said that they would like to compose them in their daily life ($M = 4.40$, $SD = 0.84$).

The user study first reveals that the preferences we defined provide a good match for the user mental model. In fact, with a high accuracy (i.e., 87%, in average), participants predicted the notification delivery. We noticed that preferences were easy to understand and compose, and the required time to set them up (a couple of minutes, in average) was considered absolutely acceptable. From these results, user-defined preferences seem to be a valid approach, and the adopted preferences facilitate users to understand what happens with their notifications.

Conclusion and Future Works

In this paper, we started to explore a new approach for smart notification systems, i.e., a preference-based mechanism that allows end-user to customize the notification delivery in multi-device environments. To take a step towards this vision, we defined a set of user preferences, along with a mobile application for their composition. Such preferences come from a careful analysis of large in-the-wild studies about notifications. We preliminary evaluated the understandability and the acceptance of the preference-based approach in a user study with 10 participants. Starting from the defined preferences and the mobile app, future works will include the development and the evaluation of a complete preference-based smart notification system.

References

[1] Piotr D. Adamczyk and Brian P. Bailey. 2004. If Not

Now, when?: The Effects of Interruption at Different Moments Within Task Execution. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '04)*. ACM, New York, NY, USA, 271–278. DOI: http://dx.doi.org/10.1145/985692.985727

[2] Brian P. Bailey and Shamsi T. Iqbal. 2008. Understanding Changes in Mental Workload During Execution of Goal-directed Tasks and Its Application for Interruption Management. *ACM Transactions on Computer-Human Interaction* 14, 4, Article 21 (Jan. 2008), 28 pages. DOI: http://dx.doi.org/10.1145/1314683.1314689

[3] Brian P. Bailey and Joseph A. Konstan. 2006. On the need for attention-aware systems: Measuring effects of interruption on task performance, error rate, and affective state. *Computers in Human Behavior* 22, 4 (2006), 685 – 708. DOI: http://dx.doi.org/10.1016/j.chb.2005.12.009

[4] Mary Czerwinski, Ed Cutrell, and Eric Horvitz. 2000. Instant Messaging and Interruption: Influence of Task Type on Performance. In *OZCHI 2000 Conference Proceedings*. ACM, 356–361.

[5] Mary Czerwinski, Eric Horvitz, and Susan Wilhite. 2004. A Diary Study of Task Switching and Interruptions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '04)*. ACM, New York, NY, USA, 175–182. DOI: http://dx.doi.org/10.1145/985692.985715

[6] Joel E. Fischer, Chris Greenhalgh, and Steve Benford. 2011. Investigating Episodes of Mobile Phone Activity As Indicators of Opportune Moments to Deliver Notifications. In *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI '11)*. ACM, New York, NY, USA, 181–190. DOI: http://dx.doi.org/10.1145/2037373.2037402

[7] Joel E. Fischer, Nick Yee, Victoria Bellotti, Nathan Good, Steve Benford, and Chris Greenhalgh. 2010. Effects of Content and Time of Delivery on Receptivity to Mobile Interruptions. In *Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI '10)*. ACM, New York, NY, USA, 103–112. DOI: http://dx.doi.org/10.1145/1851600.1851620

[8] James Fogarty, Scott E. Hudson, Christopher G. Atkeson, Daniel Avrahami, Jodi Forlizzi, Sara Kiesler, Johnny C. Lee, and Jie Yang. 2005. Predicting Human Interruptibility with Sensors. *ACM Transactions on Computer-Human Interaction* 12, 1 (March 2005), 119–146. DOI: http://dx.doi.org/10.1145/1057237.1057243

[9] Joyce Ho and Stephen S. Intille. 2005. Using Context-aware Computing to Reduce the Perceived Burden of Interruptions from Mobile Devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '05)*. ACM, New York, NY, USA, 909–918. DOI: http://dx.doi.org/10.1145/1054972.1055100

[10] Eric Horvitz and Johnson Apacible. 2003. Learning and Reasoning About Interruption. In *Proceedings of the 5th International Conference on Multimodal Interfaces (ICMI '03)*. ACM, New York, NY, USA, 20–27. DOI: http://dx.doi.org/10.1145/958432.958440

[11] Afra Mashhadi, Akhil Mathur, and Fahim Kawsar. 2014. The Myth of Subtle Notifications. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication (UbiComp '14 Adjunct)*. ACM, New York, NY, USA, 111–114. DOI: http://dx.doi.org/10.1145/2638728.2638759

[12] Abhinav Mehrotra, Mirco Musolesi, Robert Hendley, and Veljko Pejovic. 2015. Designing Content-driven Intelligent Notification Mechanisms for Mobile Applications. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15)*. ACM, New York, NY, USA, 813–824. DOI: http://dx.doi.org/10.1145/2750858.2807544

[13] Abhinav Mehrotra, Veljko Pejovic, Jo Vermeulen, Robert Hendley, and Mirco Musolesi. 2016. My Phone and Me: Understanding People's Receptivity to Mobile Notifications. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 1021–1032. DOI: http://dx.doi.org/10.1145/2858036.2858566

[14] Darren Newtson and Gretchen Engquist. 1976. The perceptual organization of ongoing behavior. *Journal of Experimental Social Psychology* 12, 5 (1976), 436 – 450. DOI: http://dx.doi.org/10.1016/0022-1031(76)90076-7

[15] Tadashi Okoshi, Hiroki Nozaki, Jin Nakazawa, Hideyuki Tokuda, Julian Ramos, and Anind K. Dey. 2016. Towards attention-aware adaptive notification on smart phones. *Pervasive and Mobile Computing* 26 (2016), 17 – 34. DOI: http://dx.doi.org/10.1016/j.pmcj.2015.10.004

[16] Tadashi Okoshi, Julian Ramos, Hiroki Nozaki, Jin Nakazawa, Anind K. Dey, and Hideyuki Tokuda. 2015. Reducing Users' Perceived Mental Effort Due to Interruptive Notifications in Multi-device Mobile Environments. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15)*. ACM, New York, NY, USA, 475–486. DOI: http://dx.doi.org/10.1145/2750858.2807517

[17] Veljko Pejovic and Mirco Musolesi. 2014. InterruptMe: Designing Intelligent Prompting Mechanisms for Pervasive Applications. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '14)*. ACM, New York, NY, USA, 897–908. DOI: http://dx.doi.org/10.1145/2632048.2632062

[18] Martin Pielot, Karen Church, and Rodrigo de Oliveira. 2014. An In-situ Study of Mobile Phone Notifications. In *Proceedings of the 16th International Conference on Human-computer Interaction with Mobile Devices and Services (MobileHCI '14)*. ACM, New York, NY, USA, 233–242. DOI: http://dx.doi.org/10.1145/2628363.2628364

[19] Martin Pielot, Tilman Dingler, Jose San Pedro, and Nuria Oliver. 2015. When Attention is Not Scarce - Detecting Boredom from Mobile Phone Usage. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15)*. ACM, New York, NY, USA, 825–836. DOI: http://dx.doi.org/10.1145/2750858.2804252

[20] Alireza Sahami Shirazi, Niels Henze, Tilman Dingler, Martin Pielot, Dominik Weber, and Albrecht Schmidt. 2014. Large-scale Assessment of Mobile Notifications. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, NY, USA, 3055–3064. DOI: http://dx.doi.org/10.1145/2556288.2557189

[21] Dominik Weber, Alexandra Voit, Philipp Kratzer, and Niels Henze. 2016. In-situ Investigation of Notifications in Multi-device Environments. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '16)*. ACM, New York, NY, USA, 1259–1264. DOI: http://dx.doi.org/10.1145/2971648.2971732