Notification Dashboard: Enabling Reflection on Mobile Notifications

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Abstract

Notifications are a key feature on current smartphones. Apps gain the attention of the users to inform them about new messages, upcoming appointments or system updates. Previous studies investigated how many notifications users receive and how users interact with those notifications. Related work explored means to manage incoming notifications. In this work, we present the Notification Dashboard to enable users to reflect on their received notifications and to identify unwanted interruptions. We conducted a user study, in which we logged participants' smartphone notifications for one month. Afterwards, we visualized the log files using the dashboard and interviewed the participants about their impressions. The results show that participants underestimated the amount of notifications and were positive about using the dashboard to reflect on their received notifications.

Author Keywords

Mobile Notifications; Dashboard; Visualization

ACM Classification Keywords

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

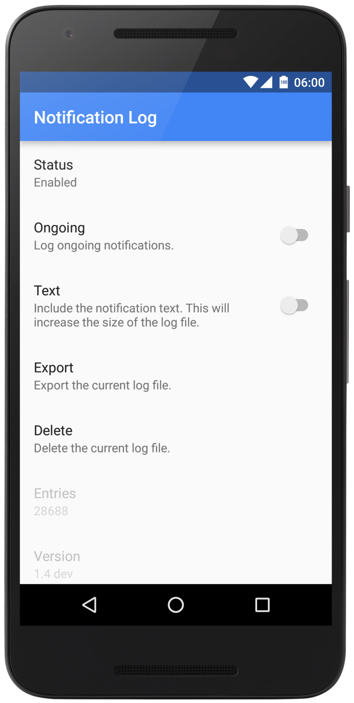


Figure 1: Screenshot of the Notification Log app that is used to generate log files for the dashboard.

Introduction and Background

On current mobile phones, apps use notifications to gain the attention of users. However, notifications are not always in the users' best interest. Apps might use notifications for the sole reason to increase interaction and therefore advertisement revenue. Because our attention is limited, it is increasingly important to find means to identify unwanted distractions. Previous work on mobile notifications focused on large-scale as well as in-situ studies and presented aggregated results. For example, Sahami et al. conducted a large-scale assessment of mobile notifications [7, 9] and gained insights in notification preferences on smartwatches [8]. Pielot et al. reported the results of an in-situ study of mobile phone notifications [5]. Mehrotra et al. investigated the effect of cognitive and physical factors on the response time and the disruption caused by interruptions through incoming notifications [3]. In terms of negative effects, work by Leiva et al. shows that interruptions caused by mobile notifications introduce a significant overhead when completing tasks [2]. Recent work by Kushlev et al. shows that smartphone notifications increase inattention and hyperactivity symptoms [1]. To counter these negative effects, a body of related work investigated delaying notifications until opportune moments [4, 6]. The results of all these studies are valuable to the research community, and developers of apps and mobile operating systems. However, the benefit for end users is only of an indirect nature.

Inspired by prior work, we saw an opportunity to visualize the notification data for the end users. We developed the Notification Dashboard, a personal single-user application that allows users to reflect on their own received notifications using visualizations. In the following sections we first introduce our implementation and subsequently explain the available visualizations. Afterwards, we summarize the results of three interviews with users of the dashboard.

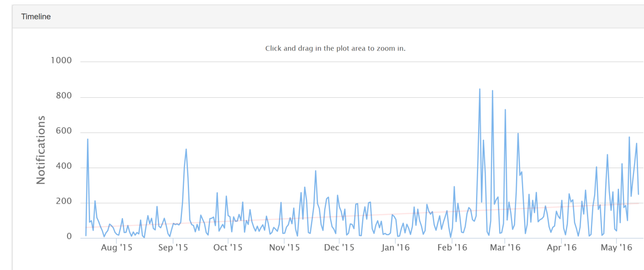


Figure 2: The timeline chart shows the number of notifications for each day (blue) and a trend line (red). In this dataset the number of notifications has increased over the course of 10 months.

Notification Dashboard

The Notification Dashboard consists of two separate components. The first component is a logging app for Android devices that records all notifications in a local log file. The second component is the dashboard itself that visualizes the log file. We will first present implementation details of the logging app and dashboard and afterwards focus on the different visualizations.

Logging App

Inspired by previous work on notifications on mobile devices [3, 5, 7], we developed an Android app that records notifications (see Figure 1). On registering a new notification, the notification data is extracted and written into a log file. Users can grant the app the permission to access the notifications and export or delete the log file. Furthermore, *ongoing* notifications (e.g., downloads or timers) can be filtered, as these types of notifications are typically updated frequently and would produce a huge number of log entries. Another option is the possibility to log either the actual text of notifications or only meta data. At the bottom of the app, the number of recorded notifications is shown.

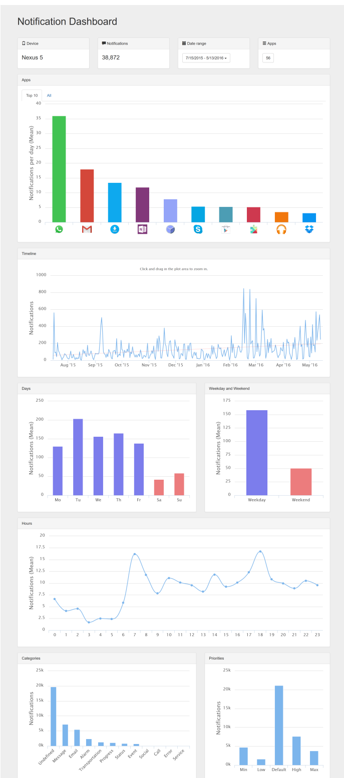


Figure 3: Full-page screenshot of the Notification Dashboard.

Dashboard Implementation

The dashboard is a single-site web application implemented in HTML, CSS and JavaScript. Apart from serving the static files, no web server is required. To protect the users' privacy, generated log files are imported and parsed completely in the browser. We use a web-based implementation to utilize the larger screen real estate on desktop computers compared to mobile devices. Still, the web application was implemented with responsive design in mind and scales according to the size of the screen and is therefore usable even on smartphones. The charts in the dashboard are created using Highcharts[1], an interactive JavaScript library.

Data Visualization

Figure 3 shows a full-page screenshot of the dashboard. Figures 2, 4 - 6 show close-up views of the visualizations in the dashboard. The visualized data originates from the personal log file of one of the authors of this paper and contains approximately 10 months of notification data. In the following, we describe the charts used in the dashboard.

General information: In the top row, the name of the mobile device which was used to log the notifications is shown. The second box shows the number of logged notifications. The third box shows the date range of the log file. Clicking on the date opens a date picker to set a custom start and end time. In the last box of the top row the number of apps that created at least one notification is shown. Clicking on the number opens a dialog with a list of all apps, the number of notifications from each app and an option to exclude the app from showing up in the dashboard.

Apps: Figure 5a displays the average daily number of notifications for every app. A toggle allows switching between the top 10 apps and all applications. Hovering over the

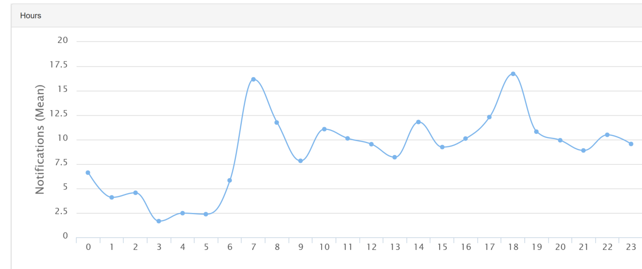


Figure 4: Aggregated view of notifications for each hour of the day. In the data set a spike at 7am and a second one at 6pm can be seen. The number of notifications quickly drops off after 0am.

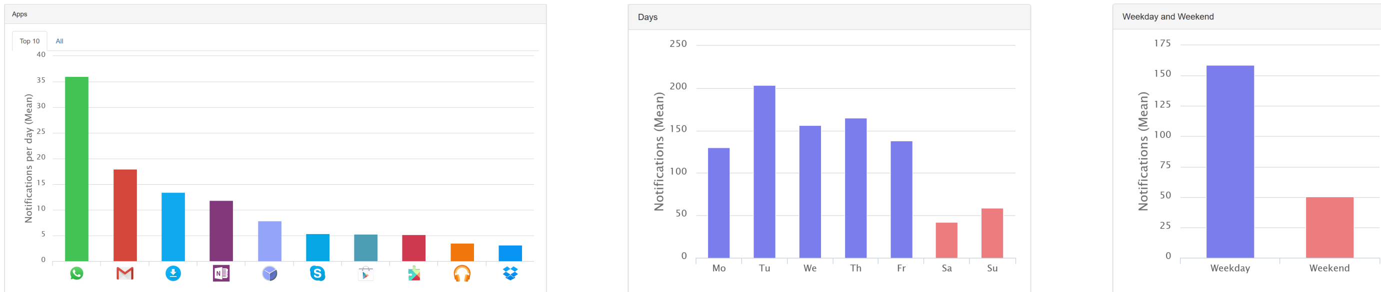
icons or bars of any of the charts causes tooltips with the exact values to appear. For easier identification, the dashboard automatically fetches app icons from the Google Play Store and extracts the dominant color for each app to color the bars.

Timeline: The timeline in Figure 2 shows the total number of received notifications per day. Further, a trend line shows if the number of notifications increases or decreases over time. It is possible to zoom into this chart to see portions of the chart in detail.

Aggregated by day: Figure 5b shows the average number of notifications for each day of the week and Figure 5c compares weekdays with weekends.

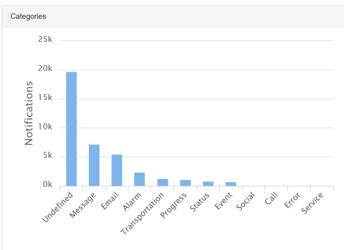
Aggregated by hour: Breaking down the data from the timeline to the week-view, the fifth row shows an aggregation of notifications for each hour of the day. Figure 4 shows the hours 0 to 23 and shows how many notifications were created for the particular hour.

[1] Highcharts JavaScript library http://www.highcharts.com/

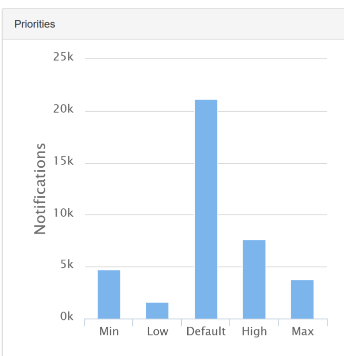


(a) Top 10 **(b)** Week (Monday–Sunday) **(c)** Weekday/Weekend

Figure 5: From left to right: Aggregated graphs showing the apps that created the most notifications, notification count for every day of the week and a weekday/weekend comparison.



(a) Categories



(b) Priorities

Figure 6: Notification categories and priorities are set by app developers.

Categories and priorities: At the bottom left the categories of the notifications are shown (see Figure 6a). The category for every notification is defined by the app that issued the notification, for example *email*, *message* or *alarm*. In a similar manner, on the bottom right, notification priorities are shown (see Figure 6b). Similar to the categories, apps can set the priority of notifications. The possible values are *minimum*, *low*, *default*, *high* and *maximum*. Notification with the *minimum* priority do not appear in the status bar and *high* priority notifications trigger heads-up notifications on newer Android versions.

Evaluation

We conducted three semi-structured interviews with participants (all male, $M = 22.3$, $SD = 2.3$) to collect general feedback on the *Notification Dashboard*. All participants were computer science students. We aimed to gather information on how people reflect on the information shown in the dashboard and their general opinion of it.

Procedure

One month prior to the interview, we asked participants to install *Notification Log* which collects meta data about their notifications (*ongoing* disabled). We briefed them on its functionality and privacy aspects. No other details were told about the study to avoid influencing them.

One month later, participants were invited to a 30-minute interview session. Each interview was held by two researchers. One researcher took notes and the other conducted the interview. The interview consisted of the following parts: First, participants were asked to estimate the number of notifications they receive per day. Further, we asked them to guess how many apps are notifying them and which one shows the most. These questions were asked before showing them the *Notification Dashboard* to evaluate their assessment of received notifications on their smartphone.

After the interview, we showed them the *Notification Dashboard* which visualizes the logs they collected over the past month. A brief introduction about the available visualizations was given, before allowing the participants the explore the dashboard on their own. After approximately 3 minutes of exploring the dashboard, we continued the interview. We asked them about information that they find interesting and how they would use this information to optimize their notification settings. We also asked if they find this information useful when integrated into the operating system itself (similar to battery statistics in Android). To collect ideas for future improvement, we asked them whether any visualization or details are missing that they would like to see.

Results
The estimation on the amount of received notifications per day shows a high deviation amongst the participants. While P1 assumed that he receives at least 100 notifications per day, P2 guessed that he received 3 per day. P3 in contrast, reportedly estimated his amount as "*often, maybe 30*". Looking at the logged data in the dashboard, they all noticed that their estimation is off by a large amount. Here, P1 received 200, P2 received 60, while P3 received 100.

When asked about the amount of apps that send notifications, we also observed a difference between the estimation and the real amount shown in the dashboard. They estimated that a small number of their installed apps are showing notifications (P1: 7; P2: 8; P3: 3), whereas the dashboard shows more (P1: 26; P2: 15; P3: 12). Specifically, our participants were annoyed by notifications from "*Google Now at 2am*" (P1), "*updates for applications, Facebook and Twitter*" (P2) and "*9gag*" (P3). As a result, P2 uninstalled these apps and P3 disabled notifications for 9gag.

After participants explored the dashboard, we asked them about their first impression on the visualizations. All participants immediately noticed that their estimations were off by a noticeable amount ("*I didn't know that Google Now is showing so many notifications.*" - P1). Further, we observed that participants tended to describe characteristics of their notification logs, such as "*it seems like I text more when I'm at the university or going out at night*" (P2) and even try to explain them ("*Peaks [in the amount of notifications] may also be due to WhatsApp notifications during [the soccer match]*" – P2). Participants also tried to generalize their notification behavior ("*On weekends, we write less with colleagues*" – P1). P3 liked the visualization but did not find anything surprising except the amount of notifications that he wrongly estimated.

When asked about a possible integration into current operating systems, P1 liked the idea that it could be used to "*detect apps that are often distracting*". In contrast, P2 stated that while these "*would be nice*", he would not benefit from it since he normally notices anything that annoys him and acts upon it. Further, P3 stated that he usually has his notification settings on silent so that "*it does not bother [him] at all if notifications are incoming*".

In terms of future improvement, all participants agreed that it should be possible to see detailed information of specific days to investigate peaks in the timeline.

Discussion
The results suggest that people are not able to estimate the number of incoming notifications. Our participants were all surprised that the actual amount of notifications are higher than the amount that they initially guessed. On the one hand, this may be due to repetitive notifications that people start to ignore because they see them often without acting upon them, e.g. Wi-Fi notifications or system updates. On the other hand, this category of notifications mostly also have a low priority, and trigger neither sound nor vibration. When asked about the first impression on the visualizations, participants indicated their interest in using the visualization to reflect on their own notification behavior. They

made this clear to us by voluntarily interpreting trends and generalizing them by referring to their usual smartphone usage behavior.

Conclusion and Future Work

In this paper we introduced the Notification Dashboard, a visualization for notification statistics to enable users to reflect on their own mobile notifications. To evaluate this first iteration of the dashboard, we conducted an interview study with 3 participants and showed them the visualizations of approximately one month of their own notifications. From these interviews we derived opportunities for improvements. In the future, we will improve the feature-set of the dashboard and make it freely available in order to assess the effect of visualizing notifications.

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