Child-centred design supported by comprehensive child application use analysis

Mohammad Hashemi
MaREI Centre, Beaufort Building
University College Cork
Cork, Ireland
m.hashemi@cs.ucc.ie

John Herbert
MISL, Western Gateway Building
University College Cork
Cork, Ireland
j.herbert@cs.ucc.ie

Abstract
Since children already use and explore applications on smartphones, we use this as the starting point for design. Our monitoring and analysis framework, BaranC, enables us to discover and analyse which applications children uses and precisely how they interact with them. The monitoring happens unobtrusively in the background so children interact normally in their own natural environment without artificial constraints. Thus, we can discover to what extent a child of a particular age engages with, and how they physically interact with, existing applications. This information in turn provides the basis for design of new child-centred applications which can then be subject to the same comprehensive child use analysis using our framework. The work focuses on the first aspect, namely, the monitoring and analysis of current child use of smartphones. Experiments show the value of this approach and interesting results have been obtained from this precise monitoring of child smartphone usage.

Author Keywords
User-Centred Design; User Experience; Human and Computer Interaction;

ACM Classification Keywords
H.5.2 [User Interfaces]: User-centered design; H.5.2 [User Interfaces]: Theory and methods.

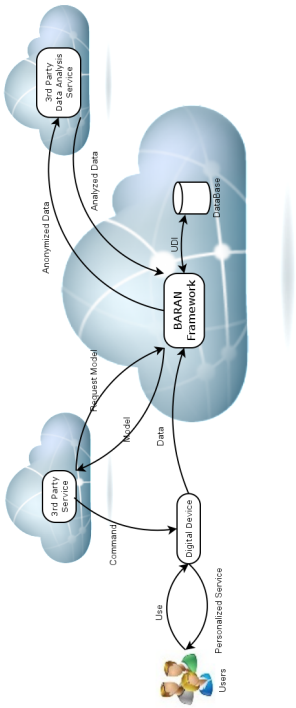

Figure 1: BaranC Framework

Introduction

Technologies have become ubiquitous, not just for adults, but also for children of varying ages, in diverse contexts, and in different countries. Designing technology for children has become important. Considering children is an integral part of the design process if the consumers of the technology include children [8]. Research has shown that children can be involved in the technology design process in a variety of ways [4]. A study reports that technologies (e.g. computers, smart-devices) were used by 27% of 5 to 6 year old on a daily basis, for an average of 50 minutes. It also reports that 80% of households with children under 6 years old owned a computer or laptop, and approximately 69% of all households with young children had Internet access. For children aged 3 to 10 years, 55% used hand-held gaming devices, 68% played on console gaming devices, and 85% used computers [11]. User-Centred Design is one conventional approaches to design [9, 7]. Contextual Design [3] pioneered a method in which the end user is at the centre of developing new technologies during the design process. The basis of these methods is that the user should be involved in the design process. However, considering children as the users makes these methods difficult. For instance, a controlled experiment in a research lab may be boring and/or difficult for children to understand [9]. An experiment was conducted for children aged 8-10 as the design of an on-line collaborative storytelling environment [1, 2]. The authors in [10] investigated the designers' strategies for designing educational software for children. These studies do not seem to study the children's interaction in their natural environment.

Understanding how children actually use the technologies in real life is the key of redesigning and improving technology. The framework, BaranC [5, 6] transparently, efficiently, and implicitly records a user's activities while using a digital device (e.g. smartphone, tablet, computer, etc.) and also records associated context data. It analyses the collected data, extracts information and knowledge from the raw data, and enables other IT systems to use the information in order to provide a better (e.g. personalized) service to a user. This paper presents results from experiments monitoring children's interactions with smartphones and tablets. We can see patterns such as differences in technology use according to age, gender.

Baran Framework

BaranC [5, 6] is a cloud-based, service-oriented, user monitoring and data analysis framework. Figure 1 provides an overview of the Baran framework and how its components work together. The current implementation provides an Android and a Windows data collector service that collects User Interface (UI) interaction and all available contextual data from internal and external sensors. It aggregates the data and sends it to the BaranC cloud service for processing and analysis. BaranC lets users manage who, how, and what information is collected. The framework explicitly informs a user about the data that is shared with 3rd parties. The user chooses what data and level of access to grant to a 3rd party. When BaranC is used to monitor interaction of children then the parents are informed and give consent on behalf of the children.

Selection and Participation of Children

An experiment to analyse how children interact with smart devices involved a number of children being asked to work freely with an Android smartphone or tablet. A range of applications were installed and used by the participants. The users were aged 5-11 years old (five 5-8 years; three 8-11 years old), four boys and four girls, located in Europe and Asia. The participants were invited because they were interested in using smartphones for various activities such

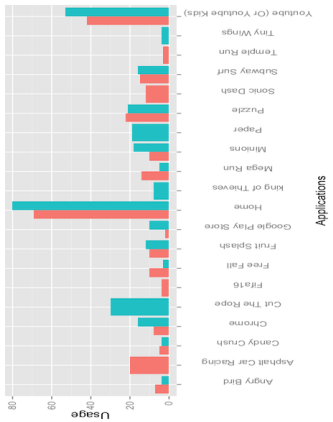

Figure 2: Application Usage for All Participants

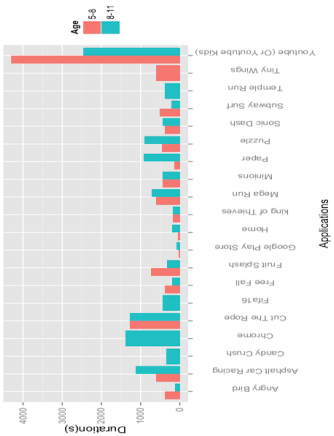

Figure 3: Total Duration of Using Applications based on Age

as playing games. The purpose of the research study was explained to the parents, and the permission of the parents (and children) was obtained for collection and anonymous use of the data. We collected in total about 36 hours of smartphone usage with 74954 interactions and 20 applications being used. Our data analysis shows that on average the children had 49 touches and 85 scrolls per application session with an average duration of 3 minutes and 52 seconds. An application session is defined as the time interval from the time an application is initiated to when it is closed.

Figure 2 provides aggregate usage information of applications for all the children and Figure 4 presents the amount of time spent on different applications. The application *Home* is the home screen and occurs between other applications as switching between applications mostly requires going to the home screen. The figures show the popularity of *Youtube* and the large amount of time spent on this applications. As the participants of this experiment are children, there are more game applications than from other categories.

Data analysis shows the differences between children of different ages in Figure 3. The figure explains how the children 5-8 years old are more engaged in using smart-devices and different applications than the older group. This group used *Youtube* application more than the others. On the other hand, it shows that the children aged 8-11 like to use *Chrome* as well as *Youtube*. There is a game called *Subway Surf* that is played more by the children aged 5-8 years old. When we studied the information about the app, we realized that it is recommended for children aged 9+[1]. Here is the definition of the 9+ group: "9+ Applications in this category may contain mild or infrequent occurrences of cartoon, fantasy or realistic violence, and infrequent or mild mature, suggestive, or horror-themed content which may not be suitable for children under the age of 9"[2]. Our study simply shows children may like to play an application that is not designed for their age group. Using a framework (like BaranC) can help application developers to know their users and design for them.

It is also interesting to consider the gender of the children; Figure 5 provides interesting statistics about boys versus girls. It shows boys like to use *Chrome* and *Youtube* more than girls. We do not focus on deep data analysis in this work, however it is possible to extract and study the actual activities a gender or age group does using the an application. Comparing how users in different categories (e.g. age, gender, location) engage with the same application can help understand the target users of that application. Figure 5 also shows the popularity of racing games (*Asphalt*) among boys in comparison to use of *Subway Surf*, *Fruit Splash*, and *Minions* among the girls. Figure 6 provides data analysis on the users' interactions (e.g. Click, Touch, Scrolling) with different applications. The figure shows that while *Youtube* is the most common app used by children, it is not highly interactive as it is used to watch video streams. On the other hand, *Tiny Wings* is a very interactive application used by user 8. Figure 8 provides a detailed analysis on the application usage, duration, and number of interactions based on the participant's gender. For instance, *Tiny Wings*, *Mega Runs*, and *Fruit Splash* are the most interactive applications. The number of interactions in *Youtube* is not high, however the length of time it is used is one of the highest. It is also used more frequently than any other applications. *Fruit Splash* is a game that is not used many times, however the users had a high number of interactions in a short time, and this shows that interactivity in this application is higher than *Youtube*. It tells the application de-

[1] https://goo.gl/9f0VEE

[2] Table 4-1 https://goo.gl/XVnmBU

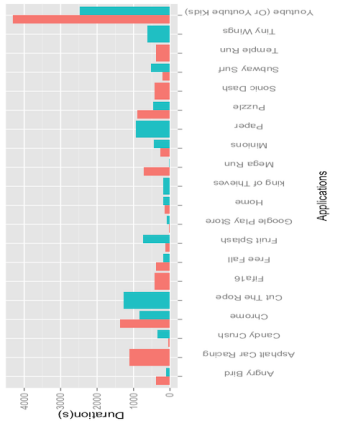

Figure 4: Total Duration of Using Applications for All Participants

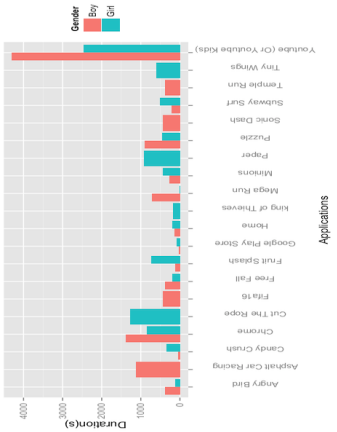

Figure 5: Total Duration of Using Applications based on Gender

veloper to improve those parts of their applications that is of interest to the real users. This figure is one of the visualization samples that BaranC can provide. The figures can be based on different parameters (e.g., gender, age, location) showing the differences for different groups of user.

Interaction Profile

It is often difficult to read and understand statistics, more especially where the data is big. Comparing users' device usage, application usage or interaction usage of a user, can be difficult for a non-technical person. Visualizing data is a method to ease reading statistics and make the data more understandable. We propose an *Interaction Profile* in order to compare two class of entities. We can compare one user's use of an application at different times (e.g. compare a work day to a leisure day), or one user's use of two different applications over the same period, or two different users use of the same application over a similar period. The Interaction Profile enables us to simply compare user's interactions. We selected two applications and two users for showing how the proposed Interaction Profile (Figure 7) can provide a clear, more understandable view of statistics. The Interaction Profile is an innovative comparison scheme. It is based on three major metrics (Frequency, Duration, and Interaction) that can be used to characterize an activity especially when using technology such as a smartphone. We also introduce two metrics derived from the main metrics (Engagement and Intensity) that emphasise other aspects of the atcivity profile.

- Frequency: The frequency is the number of times something occurs (e.g., an application is used) during the interval of the profile. For instance, if a user uses the *Youtube* application 30 times in a day, then the frequency of using *Youtube* for that user per day is 30.
- Duration: The amount of time someone spends on an activity is duration and it is in units of **second**. For instance, if a user spends one hour and five minutes on *Youtube* in a day, then the duration for use of *Youtube* for that user per day is 3900 seconds.
- Interaction: Interaction is defined as the total number of physical interactions someone engages in during an interval. In this experiment these interactions are touching and scrolling of a smartdevice. For instance, if a user uses *Youtube* and does 120 touches and 2000 scrolling, then the interaction for *Youtube* is 2120 for that user per day.
- Intensity: This metric is derived from the Interaction and Duration metrics, and it shows the interactivity of a user while engaging with an application. For instance, if a user uses *Youtube* for a short time but does a lot of interactions, the intensity of this application use is higher than a user who uses *Youtube* for a long time with the same number of interactions. Obviously the first user is more active than the second one. As it is based on the duration, for having a fair and comparable metric, we normalize the base of this metric to the same baseline such as seconds, minutes, etc.
- Engagement: The amount of time someone is engaged in doing something, is called engagement. This metric derived from the frequency and the duration metrics. It basically tells us how engaged a user is, while using something. For instance, the engagement of the user using *Youtube* five times a day for one hour is higher than the user who uses *Youtube* five times a day for half an hour.

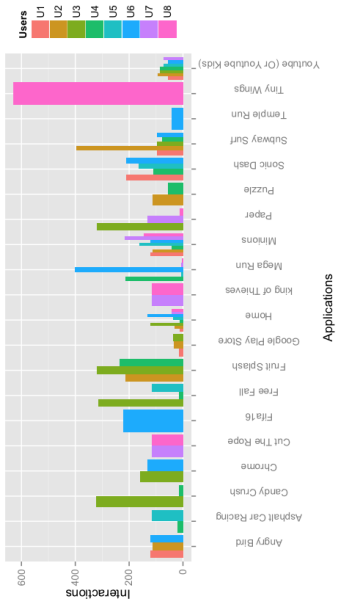

Figure 6: Children's Interaction Summary

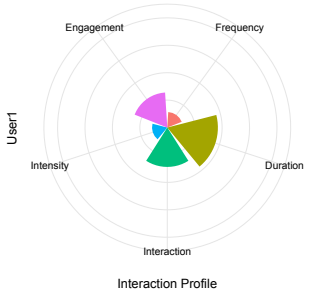

Figure 7: Interaction Profile

The Interaction Profile can be used to compare two class of entities. A comparision needs to have the same basis. For instance, in our examples, we calculated the metrics on the same basis of a full day. Moreover, in order to normalize all metrics to produce a profile, a maximum number of 10 billion is used in our calculation. In order to make it easy to visualize and compare, the Logarithm of 10 (Log_{10}) of values is used to provide a number less than 10. The final result is calculated by dividing this Logarithm value by 10 to provide a number between zero to one ([0:1]). This Interaction Profile provides us with the ability of comparing not only two users or two different applications, but also two versions of the same application to see if an update or improvement in design makes any differences. Using the BaranC framework provides developers with all the statistics about how their child users interact with their software. In order to show how the Interaction Profile can be used as a comparison method, we select two of our participants to show how they differ.

Figure 9 shows the interaction profiles of user 1 and user 3. It shows user 1 used his/her smartphone and applications less often than user 3, however s/he spends more time with it. User 1 has a higher Engagement than user 3 that shows s/he is more engaged when using his/her smartphone. On the other hand, user 3 had more interactions than user 1 even in the shorter time s/he spends with his/her device. The figure also shows the user 3 was more active than user 1 because of having a higher Intensity. All this information can be extracted from Figure 8, but it is easier to simply use the Interaction Profile as a comparison tool.

We also select the *Youtube* application and *Puzzle* game to show how the Interaction Profile can be used for comparison. Figure 10 shows how all of the participants used *Youtube* and *Puzzle*. The Frequency of *Puzzle* is higher

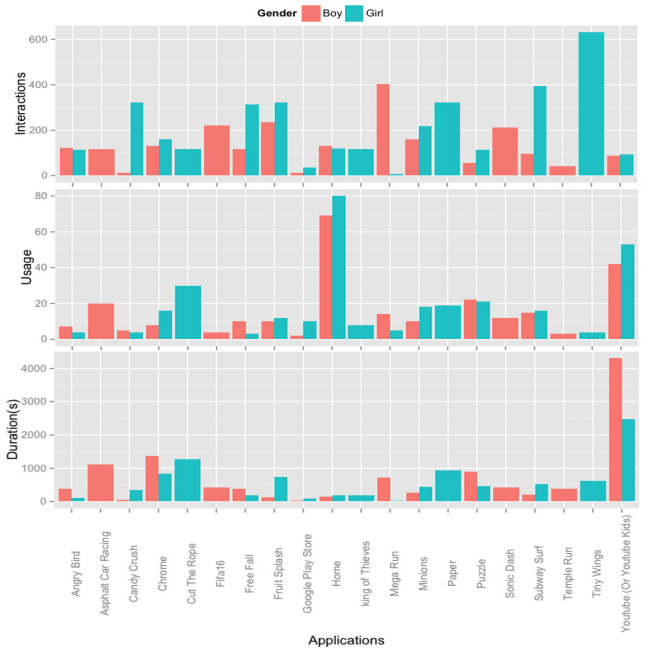

Figure 8: Application Usage, Duration, Touches, Scrolls Summary

than *Youtube*, however the Duration of *Youtube* is higher. Users' Engagement with *Youtube* is a bit higher than *Puzzle*, but on the other hand *Puzzle* was a more interactive application than *Youtube* because of having a higher Intensity. From this figure, we can conclude that *Youtube*'s users were less active than *Puzzle*'s users, but they were more engaged in watching *Youtube*.

Conclusion

A monitoring and data analysis framework has enabled us to discover and analyse which applications a child uses and precisely how they interact with them. The framework provides an opportunity to monitor children while they are in

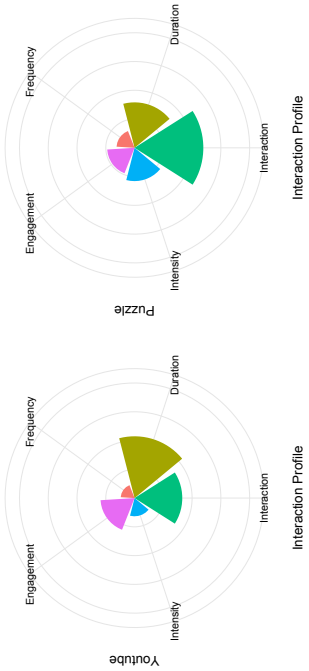

Figure 10: Application Interaction Profile of Youtube vs. Puzzle

their own natural environment without artificial constraints.

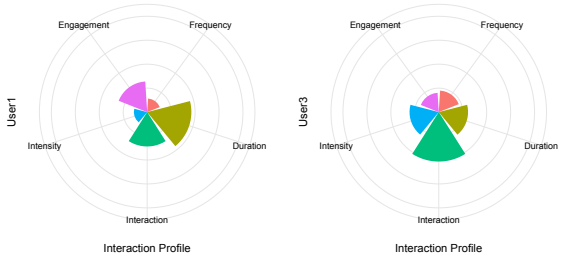

Figure 9: User Interaction Profile of User 1 vs. User 3

The statistics and data analysis results from experiments involving child participants have produced interesting insights. We present the Interaction Profile as a new way of comparing two subjects that provides an informative summary of interaction based on five useful metrics: Frequency, Duration, Interaction, Intensity, and Engagement. The approach taken to child-centred design is based on finding out precisely (in an unobtrusive way) how different child users of technology are making use of existing applications, and using this is the starting point and reference point for subsequent design activities.

Acknowledgements

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