A Novel Recommender System in IoT

Remo Manuel Frey[1], Runhua Xu[1], and Alexander Ilic[2]

I. Abstract

In Internet of Things (IoT), selling smart physical objects together with a compatible mobile app becomes an upcoming trend. The app allows to control or monitor the physical object and its sensors in an easy, ubiquitous, and user friendly way. In this post, we present a novel recommender system which uses publicly available data about these apps as a source for personalization. The proposed system infers user's physical objects from exploring the installed apps on her mobile devices like smartphones and tablets and builds a digital inventory of physical objects of each user. Then, these inventories can be used to create personalized recommendations.

A. Background

Smartphones have become our daily companions and support us in almost any situation of our daily life. We use them for communication, gaming, news reading, watching movies, payment, mobile banking and many others. The way we use smartphones is correlated with individuals' needs, interests, habits, and personality [1]. Custom-tailored content like recommendations, advertisement, personalized prices and search results can be presented to consumers, based on observed activities on their devices [2].

From the perspective of IoT, smartphones are becoming increasingly important because they are used as hubs between the physical objects and Internet. For instance, smartphones provide dashboards to manage our smart home appliance (like heating system, light-bulb, key, TV) as well as retrieving and presenting data from our smart gadgets (like pedometers, body sensors). Since there is no method to automatically get a list of individuals' physical objects, offering fitting recommendations in IoT is difficult.

Recent studies propose to gather data about installed apps on smartphones as a way to get valuable user information and to derive user profiles [3]. We believe that the installed apps are also a door opener for gathering information about the connected physical objects and we are able to automatically build a digital inventory for each consumer. Recommender systems can use these inventories for collaborative filtering and/or to offer related products and services to the consumers in a non-intrusive way. It leads to the following research question:

> *How does users' installation behavior on mobile devices enable the building of digital inventories of physical objects for recommendations systems in IoT?*

B. Solution

A schematic view of the proposed recommender system is shown in Figure 1. It consists of two parts: an app for gathering data and displaying recommendations (marked with a star icon) and a server for data processing.

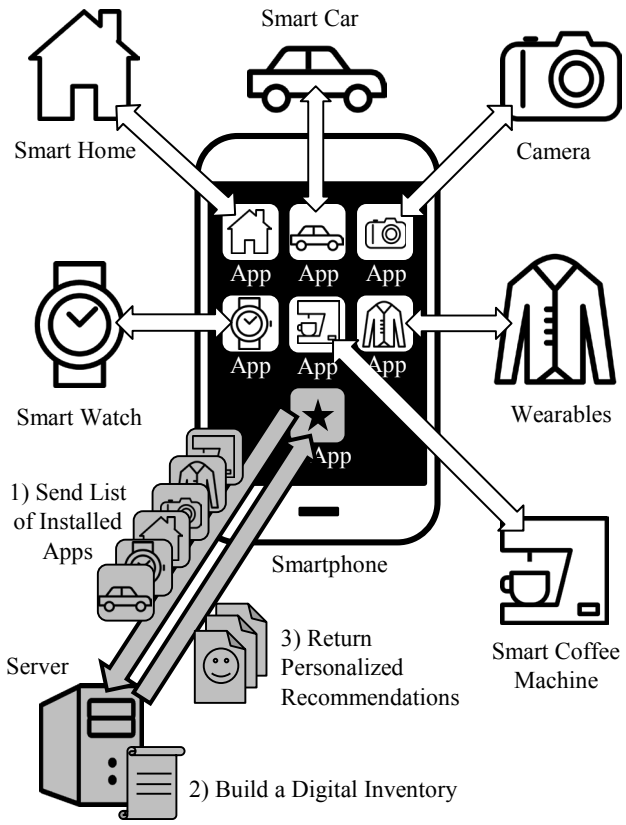

Figure 1. Schematic view of the proposed system.
The recommender engine is shaded in gray. Physical objects and corresponding apps on the smartphone are displayed in white.

1. Remo Manuel Frey and Runhua Xu are PhD students from the Chair of Information Management, ETH Zurich, email: rfrey@ethz.ch and rxu@ethz.ch, Phone: +41 44 632 4818, Address: Weinbergstrasse 56/58, 8092 Zurich, Switzerland (Remo Manuel Frey is the corresponding author and the poster presenter)

2. Alexander Ilic, an Assistant Professor from the Institute of Technology Management, University of St.Gallen, email: alexander.ilic@unisg.ch, Address: Dufourstrasse 50, 9000 St.Gallen, Switzerland

The working procedure of the proposed system consists of three steps, as follows:

1) Data Gathering from Mobile Device

As an initial step, the app sends a simple list of all installed apps to the server. From technical point of view, retrieving the list of apps installed on a mobile device can be done through calling APIs provided by Google's Android Operation System. Retrieving this piece of information does not require any additional permission from the user.

2) Building a Digital Inventory

In IoT, manufacturers tend to provide mobile apps along with physical objects to improve user experience as well as to provide better services. For instance, a smart toothbrush is sold together with an app for monitoring the cleaning process in real-time. Thus, our server looks on the received app list for apps that are related to such smart objects. The server can use a pre-defined mapping table. Or, the server goes on app markets like Google Play and reads automatically the description of the installed apps. Most app descriptions refer to the corresponding physical object because the object is a precondition for using all features of an app. In the end, the server stores the identified physical objects in a digital inventory.

3) Creating Personalized Recommendations

Based on the digital inventory from previous step, the server computes a list of personalized recommendations and sends them back to the user's device. Both collaborative and content-based filtering are possible. The inventories can also be used to study consumer needs and adoption behavior and to predict users' character traits, demographics, etc. Finally, the app presents the received recommendations to the user.

C. First Results

As a first prototype, we developed an app which is grabbing the list of installed apps from a user and sends it two our server, as described in the previous section. In March 27, 2015, we published the app on Google Play Store and advertised it on Facebook. Until June 7, we had 2410 people in total.

Based on the list of apps, we manually identified a selection of corresponding physical objects: 377 cars, 70 sports tracker devices, 4 smart watches, 11 dogs, 2 smart washers/dryers, 2 smart toothbrushes, and 67 printer devices.

Experts expect a rapidly increasing proliferation of the IoT paradigm in our daily lives in the near future [6]. Thus, the number of detected physical objects will rise significantly and our proposed system will be more powerful.

D. Discussion, Limitations and Future Work

We propose a novel recommender system which enables new business and marketing opportunities. For the first time, it is possible to automatically find out which physical objects an individual owns and uses. Companies can propose personalized offers related to these objects, even if they are not the manufacturer or seller themselves. For instance, a car washer sends a coupon to a car owner, an electronic retailer offers a special price for renewing the old camera and an app provider propose a new app to all smart watch owners.

Today, there are a number of young companies that help people to build their own digital inventory of personal items. Customers can overlook their products, manage the guarantee certificates, contact the manufacturer in case of a malfunction, use post-purchase services, etc. Unfortunately, they suffer from a big problem: Customers have to add all of their items manually into the inventory, which is cumbersome and user-unfriendly thereby preventing adoption. In some cases, the companies provide a product database where the customer can select predefined items, but the search is painful and the database is incomplete. In the best case, a barcode scanner software is provided to capture the items by the own smartphone. However, opening an app and then scanning a barcode is still complicated. Many users do not even have installed a barcode scanning app. Our proposed system overcomes this issue in a non-intrusive way.

The system can be used to build an inventory of *any* owned physical object. It is not required that the object has an electronics like a transmitter to connect with a mobile device. It is sufficient if there is an installed app related to that object. For instance, an installed app from a fashion store indicates that the owner of the device is in possession of some clothes from this store. The same holds for grocery stores. An app from a ski resorts suggests winter sport articles.

Although powerful, conducting personalized marketing might trigger users' concern about privacy [4], [5]. Our system goes even further by retrieving information about installed mobile apps and their corresponding physical objects. In order to protect the privacy of the users, we want to identify and investigate potential concerns in future work. However, there are several solutions possible. A first solution might be to explicitly ask the users for consent before gathering their data from the mobile devices. At any time, the app publishers should transparently inform about their data collecting activities and data usage. If the users accepts the disclosure, our method supports companies to offer personalized recommendations in IoT – a benefit for both, users and companies.

In future work, we develop the proposed recommender system and try to answer the mentioned research questions.

REFERENCES

[1] D. N. Chin and W. R. Wright, "Social Media Sources for Personality Profiling," in *Proceedings of the 2nd Workshop Emotions and Personality in Personalized Services (EMPIRE 2014)*, 2014.

[2] P. Smutkupt, D. Krairit, and V. Esichaikul, "Mobile Marketing : Implications for MARKETING STRATEGIES," *International Journal of Mobile Marketing*, vol. 5, no. 2, pp. 126–139, 2010.

[3] S. Seneviratne, A. Seneviratne, P. Mohapatra, and A. Mahanti, "Predicting User Traits from a Snapshot of Apps Installed on a Smartphone," *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 18, no. 4, pp. 1–8, 2014.

[4] P. T. Chen and H. P. Hsieh, "Personalized Mobile Advertising: Its Key Attributes, Trends, and Social Impact," *Technological Forecasting and Social Change*, vol. 79, no. 3, pp. 543–557, Mar. 2012.

[5] S. K. T. Lam, D. Frankowski, and J. Riedl, "Do You Trust Your Recommendations? An Exploration Of Security and Privacy Issues in Recommender Systems," in *International Conference on Emerging Trends in Information and Communication Security*, 2006.

[6] Gartner press release. "Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020." December 12, 2013. http://www.gartner.com/newsroom/id/2636073. Accessed on August 29, 2014.