Object Circles: Modeling physical objects as social relationships

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ABSTRACT
Physical products, things, and appliances will be associated with digital counterparts, such as additional product information, instructions, API's, etc.. Thus, it will become challenging for users to consciously manage access rights of data of their objects and stay aware of which data is visible to whom. This paper proposes to transfer the notion of Google's circles for managing social relationships to managing data streams of physical objects. We describe the concept and its implementation, and provide a proof-of-concept by a sample scenario. Thus, we show that object circles offer a more intuitive way for everyday users to manage the data-streams of their objects transparently.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Input Devices and Strategies

General Terms
Design, Experimentation, Human Factors.

Keywords
Ubiquitous Multimedia; Smart objects; Social networks.

1. INTRODUCTION
The Internet of Things connects digital artifacts with the physical world. Consumers, products and everyday devices are networked and equipped with smart capabilities, identifiers and sensing functionality. These so-called smart things provide new digital services and properties that go beyond objects' original physical affordances. These networks often require "dedicated software and/or proprietary protocols" [1] for monitoring and control. This adds both complexities when integrating and interconnecting objects designed as isolated service islands and when managing and using several of this objects in combination.

This paper proposes to extend the notion of social networks (SN) to things, such that the participants not only share data among friends but also among things. In particular, this paper proposes to build upon the established notion of circles which allow to organize and delegate access to information of things in the same way as friends and acquaintances can be managed in social networks today.

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The paper is structured as follows. In section 2, we present the research context and related work. In section 3, we elicit the core principles of social networks. In section 4, we derive the requirements and outline the circles concepts. We present a proof-of-concept implementation in section 5 and compare it against the requirements from section 3. Section 4 concludes the paper with a discussion and provides the perspective of future work.

2. RELATED WORK
The fundamental concept of this paper to use social networks as interfaces for device builds upon Ericsson's notion of social web of things[1].

Managing data of physical objects, however, roots back to the much older and more generic topic of managing data in supply-chains. Traditionally, there are three models of how an entity A can provide data to an entity B in supply-chain scenarios [2]: the Third Party Model introduces an information broker collecting information and maintaining it in a database, the Information Hub is a system sharing data among the parties, and in the Information Transfer Model one partner actively takes the lead of transferring information.

In the context of RFID in supply-chains, Dual ownership [3] suggests to link access to data of physical goods to the actual physical flow of those. Thus, whoever holds the products in her hands proves the ownership of a product by RFID or barcode and gets access granted to the corresponding data of the product. While this approach seems intuitive and handsome for supply-chain processes, it lacks an intuitive metaphor for everyday users, for which the circle concept is proposed in this paper.

The social access controller (SAC) [1] already goes in that direction and offers an authentication mechanism, access control management based SNs to inform about and advertise for shared smart things. A central web application creates links between the SN and the smart devices offering a service. In this paper, we are looking for a more intuitive approach of managing access rights to data of physical things.

In smart friends [4] devices become connected when a user holds them together and shakes them. It is our goal in this paper to go beyond this binary notion of data-access and to provide a more fine granular configuration.

Twitter has been investigated as a communication medium between user and system [8]. In this paper we go beyond the communication medium of social networks but also investigate how to apply metaphors for managing objects.

[1] http://www.ericsson.com/uxblog/2012/04/a-social-web-of-things/

ThingBook [9] is a prototype Facebook application for creating repositories of things and sharing opinions with friends. In contrast to that paper, this work focuses on reusing the circle's concept for managing things in a network where users can draw connections.

3. CONCEPT OF THING CIRCLES

Proximity to a physical thing is a very generic, but useful identifier of interest. Typically, when a human is close to a device, there exists a minimum level of interest: e.g., the owner of a suitcase stands close to it while waiting, people approaching a car might be interested or simply be the owner or user. For instances in logistics one can associate co-location with information need. A transport company that actually handles goods is also interested in gaining access to the freight's data while the freight is within their field of operations. Thus, it seems rather natural to establish a connection between the agency and the good being handled. This connection should then enable access to all process relevant information of a good. After losing the geographical proximity, this ability should or may be revoked.

The central part of this framework is the notion of a *circle* as a tool to organize social relations. The use of this term already exists in the human vocabulary describing social structures. It also reflects the aspect of social relationships dynamically changing over time: e.g. people travel, change workplaces, fall in love and break up. These connections therefore are constantly evolving, growing and shrinking.

Integrated in social networks this circle notion allows to organize access to data and services of physical objects. The proposed architecture in this paper uses REST-interfaces for communication. Sensing acquires the data of physical objects and shares those with local nodes, the application on top hosts the basic functionalities of storing sensors and profiles.

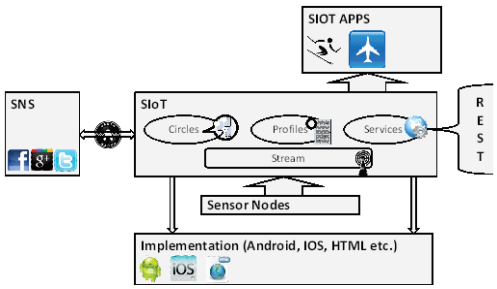

Figure 1: Social Internet of Things Architecture Model

3.1 Circles

A circle is a grouping of users that share access to information which can be restricted to a time-frame and location. The circle creator can assign names to her circles, the name is not known within the circle. The creator of the circle can add users. This user groups can be used later to define recipients for information updates. The audience is restricted to the circle, is not transitive and thus does not include friends of friends.

Beyond the scope of Google's circles[2] (see Figure 2) we allow to add people and things to the network. Furthermore, we allow to also choose a geographical and time dimension. The geographical dimension allows to only make information visible to users and things within geographical boundaries.

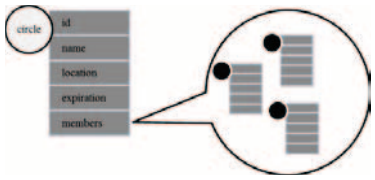

Figure 2: Sample Circle Illustration

The time dimension adds the possibility of an expiration date, such that the corresponding circle members only see information in this predefined period.

3.2 Profiles

Like a human profile on today's SNs, a thing, item or device has a list of static and dynamic information it may share. The thing profile contains a list of services the item is capable of and the requirements needed for operating its services.

A profile also lists the circles the profile owner is member of, and the other users that are in the owner's circles (see Figure 3). Based on a user's activities, e.g. scanning a barcode or NFC/RFID tag , an object can add other objects to its circles.

Figure 3: A Social IoT Concept Sample Profile

A profile could be created by the manufacturer of a smart thing and the credentials are then transferred to the future owner (e.g. buyer).

4. PROOF OF CONCEPT

The following implementation shows how to reduce the uncertainty about a passenger's luggage whereabouts when travelling by plane using the circle's concept from section 3 (see also for a video here[3]).

4.1 Software Components

The application has been implemented using Google's Android framework. The barcode scanning app provides the link to the suitcase, OAuth grants access to social networks, SL4A established the client/server communication, and Twitter implements the circle's concept introduced in section 3.

As the Google+ API does not yet allow external applications to write information stream over the API, update profile information and add users to circles, we chose to implement those functionalities by Twitter. Figure 4 depicts the mapping of Google+ circles concept to various Twitter accounts.

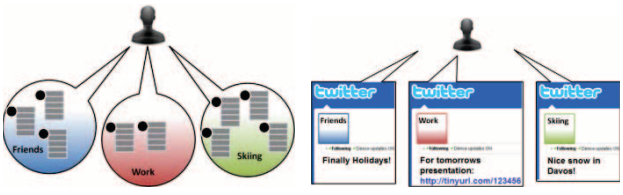

Figure 4: Mapping Circles using Twitter Accounts

[2] http://www.google.com/s2/search/social

[3] http://www.youtube.com/watch?v=Qw9e61E_dmE

Each circle (left) is implemented by a separate Twitter account (right).

4.2 Hardware Components

The prototype application was developed on a Galaxy Nexus smartphone, running Android 4.0.3. For the prototype of the Travel Application we assumed this device to be attached to a suitcase (or in future integrated into the suitcase). Thus, a suitcase becomes augmented by sensing and networking capabilities.

4.3 Functionality

Before starting a journey, the traveler packs her suitcase. She attaches stickers with a QR code on several items she wants to pack in the suitcase. These codes contain the profile id of the items (if available) or any other information about them, limited only by the 4296 characters maximum length restriction of the QR code.

4.3.1 Scanning

The items put in the suitcase are scanned by the attached smartphone. By default, each scanned item is added to the CONTAINS circle of the suitcase, which is implemented by a corresponding Twitter account as described in section 4.1. Depending on the scanned QR code, a message is created. For example, if the scanned string is a European Article Number[4] (EAN) the message contains a link to a database where the EAN information can be queried as confirmation for the user.

Figure 5: Smart Suitcase "Contains" Screenshot

As seen in Figure 5, the suitcase has started the application and notifies the user that the journey has started. In this example, the user packed two items, both identified with an EAN.

The lookup in an EAN database (e.g. http://search.cpan.org/dist/Net-Amazon/lib/Net/Amazon.pm), provides the following information:

Hauptkategorie:	Elektronische Artikel
Unterkategorie:	Fotografie
Name:	Digitalkamera
Detailname:	Panasonic Lumix DMC-TZ 5 EG
Beschreibung:	
Hersteller:	Panasonic
Herkunftsland:	Großbritannien
Validiert:	25 %

Figure 6: EAN Query Sample Result

[4] e.g. http://search.cpan.org/dist/Net-Amazon/lib/Net/Amazon.pm

As mentioned, the message that is published can easily be modified and adapted to different needs. Other possible solutions could be to include ISBN numbers for books, or UPC for other products.

4.3.2 Luggage Check-in

As the journey continues the passenger checks-in her suitcase at the airport. The relevant flight information from the boarding pass is aggregated, converted into an image of a QR code, and uploaded as the new twitter profile image. This code is visible to anyone, displayed by the attached smartphone (or in future ink displays on the suitcase).

4.3.3 Airport Ground Handling

Every member of the airport logistics staff has now the ability to interact with the luggage by scanning the profile image and becomes a follower of the suitcase on Twitter. This relationship, however, is limited for the duration of the journey only. When the suitcase reaches its final destination the ground staff is deleted from the followers list.

The adding of staff to the suitcase's circles provides transparency to the owner and indicates the people interacting with her belongings.

4.3.4 Location and Position

Once checked-in the suitcase constantly updates its position and publishes this information on the user's profile. This provides continuous awareness for the passenger about her luggage's whereabouts. This information is only temporarily published while the journey lasts. In the prototype – due to Twitter's message format – a Tweet is created saying: "I am here" followed by a link to Google Maps (e.g. see Figure 7).

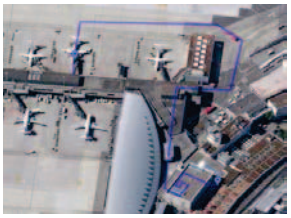

Figure7: Luggage Sample Position Path

The interaction with different items and humans results in the setup as shown in Figure 8.

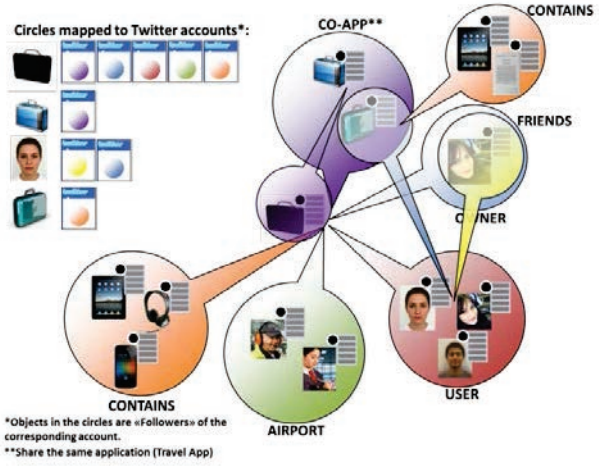

Figure 8 Travel App Circles

5. RESULTS

For objects to interact proactively, a standard protocol is required as well as a mechanism to discover functionality and services that are provided. The prototype described in section 3 does not implement this as Twitter lacks a convenient way to store this service information. The notion "spontaneously" is fulfilled at a certain degree by the Travel App where the app autonomously updates and publishes relevant information about the suitcase.

Once a smart device is programmed and ready to use it should adapt its behavior according to events from the physical world. The proposed framework partially fulfills this requirement by providing a basic interaction principle between devices running in the social object network.

The prototype application makes use of the sensors embedded into the smartphone. The integration into social networks allows to embed the sensor information into the user's social network streams she is already familiar with. Future work will focus on providing access to an object's services via RESTful APIs.

6. DISCUSSION AND FUTURE WORK

The focus of this paper is to adapt the metaphor of Google's circle of social networks to managing data of physical objects.

Building upon the circle concept provides an intuitive way for users to treat object streams in a similar way they already deal with updates from friends in social networks. Scalability is simply forwarded to the powerful infrastructure of today's social networks.

As the mobile phone has transformed from a device for making phone calls into a tracking device, camera, map, online guide, compass, accelerometer, and flashlight also social networks may turn into dashboards of information updates regardless of their human or machine source.

Integrating sensing into existing social relations, amplifies the ability to create new applications quickly and more intuitively.

The concept presented in this paper has been evaluated by a proof-of-concept implementation. As Google+ does not yet allow access to its API for writing information, this paper has used Twitter to emulate the circles concept. Twitter, however, allows users to express interest to follow another, whereas with circles the creator picks the members added to the circle. Furthermore, circle members do not become aware about the specific circles they get added to. In order to prevent users from following accounts that were not meant for them Twitter features a mechanism such that the owner of the account must grant permission to the requesting user who wants to follow.

For the application that was built in this paper the substitution of Google+ circles with Twitter accounts was sufficient. Hopefully, for future work Google+ could be used directly.

The difficulties encountered while developing the concept framework mainly come from the fact that a system which derives its advantage from a growing user base, has a difficult start since at the beginning there are almost no users, and thus there is little motivation to adapt[5].

Therefore, the next step of future research would be to investigate application areas and domains that would motivate larger groups of people to participate in a Social Internet of Things. Another possible area for future research is to define metrics (e.g. the number of interactions), which would allow to compare the circle concept in specific applications such as logistics with traditional information sharing frameworks. The universal applicability of object circles has yet to be proven in future implementations.

From a technological point of view, the Social Internet of Things is possible to build, but how users react to information streams from objects appearing in their social networks has yet to be tested in practice. This will also depend on the ability of visualizing the connections and circles across a user's objects in a comprehensible way.

Ultimately, we propose to abandon the traditional "monitor and control" scheme and apply other established mechanisms as social networks as a new way to interact with things that surround us.

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[5] This situation is often referred as „user paradox" or sometimes „fax paradox". There is little use of buying a fax machine, when nobody else possesses such a device. Only after the first wave of early adopters participate in this new technology, it makes sense to the others to buy one.