Reconciling Privacy and Data Sharing in a Smart and Connected Surrounding

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1 INTRODUCTION

When Alice goes trekking in the French Alps with friends, she is equipped with a pedometer to measure her efforts, takes pictures using her smartphone and uses a mobile coach app to monitor her trip and GPS trail. But how could Alice have a transversal view of the personal data she generates and how could she share part of her data with her friends?

The Personal Cloud paradigm emerges[1] (e.g., Cozy Cloud, ownCloud, Databox to cite a few) and holds the promise of a Privacy-by-Design storage and computing platform where each individual could gather her complete digital environment in one place and share it under control. Conjointly, smart disclosure initiatives pushed by legislators (e.g., EU General Data Protection Regulation) and industry-led consortiums (e.g., Blue Button for medical records in the US, Midata in the UK, MesInfos in France) give shape to this paradigm by letting individuals getting their personal data back from the applications that collected them. Hence, Alice could link her personal devices to the personal cloud platform of her choice and then manage the personal data she generates when trekking and regulate data sharing at will.

However, the personal cloud paradigm causes a gravity shift of data management and data security from organizations to individuals, who are usually not database administrators nor security experts. Unfortunately, the main existing access control models (e.g., RBAC, ABAC or TBAC [2]) are geared towards central authorities and require a deep expertise to define users, roles and privileges. Some decentralized models have been proposed to let individuals manually define their own sharing preferences, often based on Web of Trust-like approaches [8] or on the owner’s social graph [3], but offer limited expressive power and poorly cope with the versatile nature of the personal cloud. To tackle this issue, several works aim to ease the sharing administration. For example, [5, 12] give the possibility for the owner to share any kind of personal data through the use of attribute-based sharing rules, while [4, 7] explore machine learning techniques to automatically infer the best sharing policies. However, they provide little means for individuals to control the actual effects of their policies and could actually result in unexpected data leakage. This contradicts a founding principle of the Personal Cloud paradigm, namely enabling individuals making sovereign decisions about the sharing of their data [1]. The problem is exacerbated in a ubiquitous and smart surrounding producing continuous flow of daily activity events.

We derive from these statements a new sharing paradigm dedicated to the personal cloud context, called SWYSWYK (Share What You See with Who You Know). SWYSWYK relies on two founding principles: (1) provide intuitive means to derive sharing rules directly from the personal cloud content and help the personal cloud owner administering the resulting sharing policy by visualizing and sanitizing its net effects and (2) provide a secure personal cloud architecture giving tangible guarantees that the sharing policy will be properly enforced, whatever the security expertise of the owner.

In [11], we investigated point (2) and proposed a secure architecture combining untrusted, isolated and secure execution environments. [10] presented a practical instantiation of this architecture where the reference monitor runs into a secure hardware device. In [9], we focus on point (1) and introduce the semantics of the SWYSWYK sharing paradigm and discuss the specifics of its administration.

This demonstration focuses on point (1) with the goal to assess the practical interest of our paradigm. To this end, we have integrated SWYSWYK in a real personal cloud platform, namely Cozy, and apply it to a smart surrounding scenario inspired by Alice’s one. A video of the demonstration is available online1. We refer to [10] for a demonstration focused on the security and scalability of the platform in a constrained environment.

In this paper, Section 2 presents the SWYSWYK baseline, Section 3 gives the scenario and Section 4 concludes.

2 SWYSWYK PARADIGM

2.1 Baseline

SWYSWYK is not yet another access control model. It is rather a new sharing paradigm, helping the derivation of expressive access control rules directly from the personal cloud content and providing convenient tools to administrate the resulting policies. The originality of SWYSWYK relies on two core principles helping circumventing the aforementioned difficulties of data sharing in the Personal Cloud context:

Documents are rules. The personal cloud content on its own conveys intuitive sharing rules, e.g., share pictures and related events of a trek with people who appear on these pictures and as such are identified as participants in that trek. Such rules should be straightforward to express, as the related permissions could be derived from the documents’ content. The subjects targeted by the document, called identifiers [6], should be extracted from the document content and enter in the rule definition. We call reflexive sharing rules the rules based on this principle.

Subjects and objects are documents. The content of a personal cloud also intrinsically describes the individual’s acquaintances under different forms (e.g., contact files, identity picture.) and conversely, acquaintances are associated with pieces of information in the owner’s space (e.g., agenda entries, photos on which a friend appears). A corollary is that for each permission granted to a subject $s$ on an object $o$, viewable documents should represent $s$ and $o$. More generally, the result of a sharing policy (sets of sharing rules) must be viewable by the personal cloud owner, who can thus precisely understand what is the net effect of this policy. For example, a stream of GPS tracks may be represented

1http://wanda.inria.fr/demos/videos/swyswyk_model.ogv
as trajectories on a map and time series of activities logs could be represented in graphs.

The combination of these principles gives substance to the Share What You See with Who You Know (SWYSWYK) paradigm. This is in direct opposition with existing approaches that are either very limited and manual, or based on complex and opaque computations that cannot be easily understood by the end user.

2.2 Sharing Paradigm Semantics

SWYSWYK aims at providing simple expressions for sharing rules and make the sharing policy self-administered when the personal cloud content evolves. We show here how this can be captured within simple semantics, combined with a set of simplifying assumptions. First, our sharing paradigm relies on a closed policy, i.e. every action not explicitly granted is denied. Actions are CRUD operations on documents in the personal cloud. The paradigm supports only authorizations (positive rules) but allows the owner to post-filter the produced Access Control List (ACL) when exceptions need to be declared. Consequently, there is a direct translation between sharing rules and sets of ACLs: an action is granted to subject s on document d iff (s, d, a) ∈ ACL and is denied otherwise. The sharing is by construction consistent (the decision is unique), complete (the decision always exists) and can be evaluated in logarithmic time.

For the sake of conciseness, we do not formally define here all the notations and operators of SWYSWYK. Rather, we illustrate the paradigm through a single type of sharing rules, namely the reflexive sharing rules and refer to [9] for a complete description.

Reflexive sharing rules. These rules express the sharing of documents with subjects appearing on it. They implement the documents are rules principle and are thus considered as first-class citizen rules:

\[
ACL \leftarrow \{(s, d, a) \in S \times D \times A | \text{Filter}(d, Q) \land \text{MatchS}((d, S(s)))\}
\]

Filter and DI are user-defined, platform dependent, functions. Filter returns true if a document d of the personal cloud satisfies the qualification Q, that can be expressed on the metadata or on the content of d. DI extracts identification traits of individuals, denoted next by IT, from d. IT must uniquely represent a subject in the personal cloud and can combine simple attributes (e.g. email, phone number) or complex representation (e.g., facial features, fingerprint). SI and MatchS are internal SWYSWYK operators. SI returns the IT from a registered subject s and MatchS returns true if the compared ITs are equivalent. Below are various illustrations of reflexive sharing rules.

Example 1. Share the pictures taken during my trekking sessions with the people appearing on it:

\[
\begin{align*}
Q : \text{docType} &= \text{photo} \land \text{tagGallery} = \text{trek} \\
\text{DI} : \text{face detection algorithm} \\
\text{MatchS} : \text{here, compares the facial features extracted from DI with the ones returned by SI from known subjects.}
\end{align*}
\]

Example 2. Share the minutes of meetings with the attendees:

\[
\begin{align*}
Q : \text{docName} &= \text{minutes-%.doc} \\
\text{DI} : \text{extract attendee names from a minutes document}
\end{align*}
\]

2.3 Sharing Administration

To make the sharing paradigm practical, subject declaration and maintenance should be (quasi) automatic while respecting the owner’s privacy. In SWYSWYK, the notion of rule consistency concretizes the fact that the effects of all rules can be visualized (and then easily controlled by the owner), the notion of exceptions permits customization of these effects according to the owner’s preferences, and subject administration can be automatically performed such that the set of subjects grows along document insertions and rule declarations with minimal interactions.

Rules Consistency. A SWYSWYK sharing rule is said well-formed iff it only produces ACLs involving viewable documents shared with recognizable subjects: \(\forall sr \in SR, \forall acl \in ACL, acl(d) \in DV \land acl(s) \in DS\), where SR is the set of sharing rules, DV the set of viewable documents and DS the subset of viewable documents characterizing a unique subject. Any acl which does not satisfy this condition is filtered out.

Rules Exceptions. Instead of introducing introduction rules to capture exceptions, which makes the net effects of the resulting policy complex to apprehend, we simply give the owner the ability to filter out the permissions which hurt her privacy (considered as suspicious ACLs). We introduce three types of watchdog triggers to highlight suspicious permissions:

\[
\begin{align*}
\text{Allowed}(Qs, A) &\rightarrow \{(s, (d, a)) | (s, d, a) \in ACL^* \land s \in Qs(S) \land a = A\} \\
\text{Who}(Qd, A) &\rightarrow \{(d, (s, a)) | (s, d, a) \in ACL^* \land d \in Qd(D) \land a = A\} \\
\text{Which}(Qg, Qd, A) &\rightarrow \{(s, (d, a)) | (s, d, a) \in ACL^* \land s \in Qg(s) \land d \in Qd(D) \land a = A\}
\end{align*}
\]

ACL* corresponds to the set of newly created/updated ACLs. What identifies, for each sensitive subject, the new set of (document, action) she is granted to (e.g., which new documents can be seen by my boss?). Who identifies, for each sensitive document, the new set of subjects with granted action a on them (e.g., which new subjects have a read access to my medical records?). Finally, Which identifies new ACLs combining a selection of (sensitive) subjects and documents (e.g., which new authorizations my colleagues have on my family photos?).

Subjects Administration. New subjects can automatically be created while inserting new contact files or address book entries. The IsS operator is invoked each time (1) documents are created or updated in the personal cloud and (2) a new rule invoking IsS is defined, thus enriching the set of subject S along document insertions and rule declarations as side-effects of the function. Each s \(\in S\) is made of the extracted identification traits and at least one generated credential for the authentication.

2.4 Sharing Enforcement

General principle. The creation, maintenance and evaluation of a set of SWYSWYK permissions are as follows: (1) the owner creates sharing rules and watchdog triggers to be applied on her personal cloud; (2) a rule translator translates the selected rules into candidate (ACL*) and suspicious (ACL?) ACLs and materialize them; (3) the owner checks the suspicious ACLs at will and accepts (ACL*) or rejects (ACL?) them using the administration GUI; (4) the reference monitor authenticates subjects and evaluates Allowed (i.e., Allowed (s, d, a) = true if f (s, d, a) \in ACL*) and delivers the requested documents accordingly.

ACL production and maintenance. Five operators are required to translate any sharing rule into ACLs, namely Filter, DI, SI, IsS and MatchS. The data flow between the operators to translate a reflexive sharing rule into ACLs is shown in Figure 1. At declaration time, the rule tree is evaluated over all documents of the personal cloud. First, Filter operators are evaluated at the leaf of each branch to select the targeted subjects documents (right
branch) and the targeted objects documents containing identifi-
ies (left branch). Then DI operators extract the list of ITs from
the targeted subject documents (left branch) and from the objects
documents (ITs of the identifiies). In the right branch, IS tries to
match the extracted ITs with the subjects already registered in S,
then IS appends the identified ITs to each subject. Finally, MATCH
joins the left and right branches on subject ITs and produces
the (candidate) ACLs. At insertion of a new document d in
the personal cloud, the Filters of all rules are evaluated against d to
check whether new candidate ACLs can be produced.

3 DEMONSTRATION

The objective of this demonstration is to show that the SWYSWYK
paradigm makes sense in concrete environments. Hence, it con-
siders a ubiquitous surrounding scenario with connected smart
deVICES producing continuous data streams that are gathered and
stored in the Cozy personal cloud platform. SWYSWYK has been
partially integrated in Cozy, a simplified version being part of
the server stack.

3.1 Demonstration platform

The platform consists of an Android smartphone, a Withings
smart watch and a local Cozy instance running on a laptop with
Ubuntu 16.04. Additionally, several Cozy instances running on a
remote server are used to simulate other subject’s personal clouds.
Pictures and GPS tracks are synced with the local Cozy instance
thanks to the Android Cozy app. Data from the smart-watch
is retrieved through the Withings’ API. The Cozy stack running
on the laptop is implemented in Go and stores documents in a CouchDB database. The Cozy apps are developed in
JavaScript, with the React framework.

3.2 Demonstration scenario

The demonstration focuses on the usage of the SWYSWYK para-
digm. The scenario is composed of four steps, as summarized in
Figure 3 and described in the video accessible online:

Step 1 - Data collection: this step illustrates how surrounding
data produced by smart devices can be collected by the Cozy
platform to be further exploited. A Cozy instance is populated
with a set of predefined documents and timely integrates data
produced by Paul’s smartphone and pedometer. A Sharowalky
application developed on Cozy (for illustration purpose) manages
Paul’s trekking data, namely his photos, GPS trails and physical
activity. The attendees are invited to connect to Cozy as Paul (the
personal cloud owner and incidentally co-author of this paper),
open the Sharowalky app and browse days of trekking.

Step 2 - Sharing definition: the Sharowalky app proposes the
attendee to share the photos of a trekking day with Paul’s friends
appearing on them (among which Riad). The GUI presents the
semantics of the underlying sharing rule, that is a typical SWYSWYK
reflexive rule represented as logic-based predicates on Cozy meta-
data. The GUI allows the attendee to identify that Riad has been
granted access to certain pictures of the circle, confirmed when
connecting to Riad’s personal cloud. The attendee can also share
the GPS and activity trails of the circle with Riad very easily.

Step 3 - Sharing administration: the access control console al-
lows the attendee (playing Paul’s role) to visualize and control the
net effect of the current access control policy (set of all existing
sharing rules). All resulting permissions are shown as viewable
ACLs, i.e., triples <subject, object, permission> where each subject
and object are personal cloud documents which can in turn be
visualized. The GUI brings to light a suspicious permission that
the attendee is invited to remove (or confirm according to her
will).

Step 4 - Dynamicity: the demo operator finally selects from the
Cozy the set of pictures taken during the conference, showing
groups of people. Then, he takes a selfie with a demo attende and
creates her contact based on the photo, triggering her registration
as a subject. This automatically grants her a read access on all the

2 https://cozy.github.io/cozy-stack/sharing.html
conference pictures on which she appears, including the selfie and forthcoming ones, thanks to a pre-trained face recognition model.

3.3 Demonstration results
The demonstration shows an implementation of the SWYSWYK model in the Cozy platform. The semantics of the model and its administration principles, based on the combination of the documents are rules and subjects and objects are documents mottos, opens to a set of benefits:

Ease-of-use. The content of a personal cloud, which describes Alice’s acquaintances, and conversely, acquaintances which are associated with pieces of information of Alice, are used to express sharing rules. Most interesting rules could be easily shared via the Cozy marketplace, and reused among interested users.

Self-administration. The sharing rules are self-administrated while the personal cloud content evolves. Typically, new subjects (attendees) are automatically created while inserting new contact files or address book entries and a search of correspondences with potential content to share with them is automatically triggered.

Visualization. Subjects and objects are all viewable documents of the personal cloud. Hence the net effect of any sharing policy can be visualized and precisely apprehended by Alice (e.g., the GPS tracks pictured in a map that she is ready to share with a subject represented by her identity picture).

Control. Administration tools are provided to ease the detection of suspicious permissions and sanitize the access control policy. Pursuing this objective, watchdog triggers highlight newly generated ACLs involving sensitive subjects, documents and the associations of presumed incompatible subject/object pairs.

4 CONCLUSION
Finding new ways for the individual to intuitively share personal data and apprehend the real effects of their sharing policies is paramount. This is particularly true in a ubiquitous context where highly sensitive personal data (e.g., well-being data, daily activity logs) are produced at an increasing rate by smart appliances. Gathering these data in a personal cloud allows the definition of new transversal services of great value for the individual and holds the promise of a better privacy than storing them in a central cloud. However, appropriate sharing tools are needed to regulate data sharing and prevent individuals from exposing their digital life because of too permissive sharing policies. This demonstration shows how the SWYSWYK model tackles this challenge. We hope that this work contributes to a new step in the privacy preservation of personal data.

REFERENCES

Figure 3: Demonstration scenario.