

Designing Information Systems Which Manage or Avoid Privacy Incidents

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Abstract. In this paper, we consider an information system (IS) to be a set of technologies together with a set of rules about those technologies. An IS is considered to be prone to a privacy incident if it does not fully protect the private information of a user or if a dishonest user can take advantage of the privacy protection offered by the IS. This work identifies the potential privacy incidents that may occur in an IS, and proposes a framework, the MAPI Framework (Manage or Avoid Privacy Incidents), which designs IS to manage or avoid privacy incidents. The MAPI Framework can also be used for evaluating IS by identifying the missing or inappropriate technologies which may lead to privacy incidents.

1 Introduction

Every day, Internet users employ information systems (IS) such as e-commerce, e-payment, e-bank and e-mail systems. These information systems may fail to respect the privacy of users because users are required (by the IS) to reveal their private information to non-trusted entities, with the possibility of misuse of that information. For example in a traditional e-commerce system, a purchaser needs to reveal private information (e.g. delivery address, full name, email and the desired products) to a non-trusted entity. As a result, the purchaser is exposed to the danger of a privacy violation. Privacy enhancing technologies (PETs) which protect the privacy of users are available, but even PETs may become the subject of abuse by malicious users, resulting in a privacy incident.

In this paper, we define privacy incidents as undesired events which may occur in two cases: a) the privacy of a user is violated or b) an attacker misuses the technologies offering privacy in order to hide his or her identity.

An IS which manages or avoids privacy incidents is referred to as a MAPI (Manage or Avoid Privacy Incidents) information system. An IS may *avoid* privacy incidents by not revealing a user's private information to non-trusted entities, while an IS may *manage* privacy incidents by holding accountable those users who abuse a PET. Thus, a MAPI IS should enhance accountability functionalities in order to handle privacy incidents. For the purposes of this paper, we define **accountability** as a service which gives honest entities the ability to identify and reveal information about the lifecycle of a privacy incident. Although in some areas accountability may have a

broader scope, in this paper we are only interested in it in relation to privacy incidents.

An IS consists of a set of technologies and rules. The combined components (characteristics and functionalities) of these technologies characterize that IS. The technologies which help an IS to be compatible with a MAPI IS are considered to be MAPI technologies. The components of an information system's technologies are also considered to be components of that IS.

This paper describes a number of logical steps (shown in Figure 1) which can be used in order to identify the required components of MAPI IS and it proposes a framework (the MAPI Framework) based on these components. The MAPI Framework allows information system designers evaluating existing IS or developing new IS to determine whether an IS is compatible with a MAPI IS. In case an existing IS is not MAPI compatible, the framework identifies the missing components.

We organize the paper as follows. In the next section, we describe related work. In Section 3, we identify those cases which may produce a privacy incident. In Section 4, we propose the MAPI Framework; and we conclude the paper in Section 5.

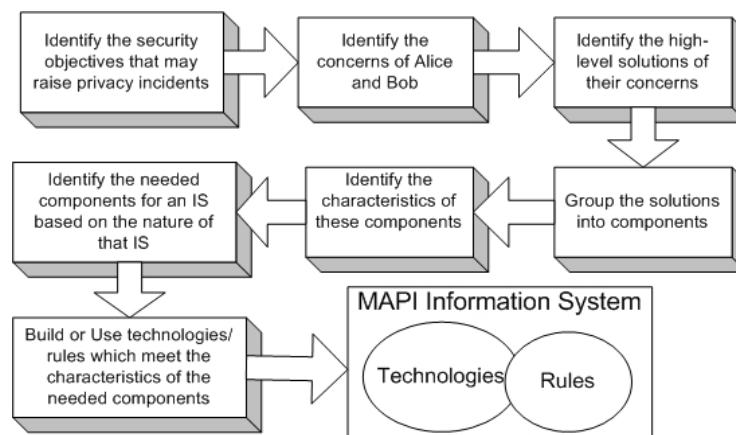


Figure 2- Steps we need to follow in order to build MAPI Information Systems

2 Related Work

There is extensive work in the area of privacy [5, 7] and accountability [8, 9]. However, much of this work examines privacy and accountability separately. This approach has led to the development of solutions (technologies, information systems and architectures) which are often incompatible.

There is limited work in the area of balancing privacy and accountability (e.g. [2, 6]). There are few technologies offering communication anonymity to users which also offer accountability even if conditions are added. We argue here that accountability alongside privacy is a necessary objective not only for identifying an abuser, but also for discouraging potential abusers from initiating an attack. In addition, many privacy

technologies offer privacy only to the communication identity (and the location) of the user. Their aim is not to protect private information of other users such as their credit card information or their email address.

There are several definitions of privacy available in the literature. The most well known definition is “the right to be let alone” [12]; however, this is an historic concept and not applicable in today’s electronic information environment. We adopt the definition given in [16], which is more appropriate to the information age and which defines privacy as “the individual right of humans to determine, when, how, and to what extent information is collected about them during the course of the digital business transaction; the right to be aware and to control the beginning of any interaction or data gathering process; and the right to choose when, how, and to what extent their personal information is made available to others.” This definition is of most practical use given our research setting and objectives.

For the purposes of this paper, we need accountability just for managing privacy incidents by making attackers responsible for their actions. Note that there are security incidents which are not privacy incidents; for example, non-delivery to a buyer of an on-line product is not a privacy incident. However, a seller misusing a buyer’s delivery address is considered to be a privacy incident in our work. Non-privacy incidents are out of the scope of this paper.

In the next section, we identify the situations in which a privacy incident may occur.

3 Cases of a Privacy Incident

Our framework, which is described in detail in Section 4, supports the scenario where Alice communicates with Bob and reveals private information to Bob through the Internet. Alice and Bob do not trust each other. Bob will identify and accuse Alice only in case she acts inappropriately, while Alice will enjoy her privacy as far as she act appropriately.

Alice considers her privacy from the following three perspectives (security objectives): confidentiality, integrity and availability as clarified below. The following cases represent the potential privacy incidents that Alice and Bob face with respect to these three items.

- *Confidentiality*: Only the parties who are authorised by Alice should have knowledge of any private information related to her. A lack of confidentiality may violate the privacy of Alice in the following three cases:

Case 1: *Alice exchanges her private information with Bob through a public channel, such as the Internet, and an eavesdropper accesses her private information.*

An example is when Alice reveals to Bob her preferences about a political party, and the government is monitoring her messages.

We assume that it is Alice’s responsibility to protect the revealed information until the revealed information reaches Bob.

Case 2: *Alice reveals her private information to Bob and authorises only him to access the information. However, Bob reveals her private information to other entities.*

An example of this case is, when Alice reveals information about her health condition to a doctor and that doctor, without having her authorisation, makes this information available to an authority.

We assume that Alice has no option but to rely on the honest behaviour of Bob despite the fact that Alice does not trust him.

Case 3: *While Alice is communicating with Bob, the intermediate entities (between Alice and Bob) know that Alice is communicating with Bob.*

We assume that Alice may decide that nobody should know that she communicates with Bob (not even Bob).

- **Integrity:** Alice should be able to make corrections or modifications to any of her private information that is under the control of other entities. A lack of integrity may violate the privacy of Alice into the following case:

Case 4: *Alice revealed her email address to Bob while she was buying a product online from his web site. A few weeks later, after she has received the products, she wants to replace that email address with a new email address. However, Bob allows Alice only to add a new email address.*

We assume that Alice should not rely on the good will of Bob to let her modify her own private information.

- **Availability:** Private information of Alice should always be available to her. A lack of availability may violate the privacy of Alice in the following case:

Case 5: *Alice reveals information (not necessarily private information) to Bob, in order for Bob to convert the information into private information of Alice.*

An example is a student (Alice), who writes an examination. The student gives answers to the examination questions in order for the teacher to produce a grade. That student has the right to know her results.

We have thus identified the privacy concerns of Alice, and now turn to the concerns of Bob. Alice may harm Bob in the following cases:

Case 6: *Alice sends inappropriate information to Bob.*

Examples of inappropriate information are, stolen credit card information and spam emails.

Case 7: *Alice attacks Bob's infrastructure.*

Examples of attacks are, when Alice compromises a server or when Alice gathers unauthorised information from Bob's database/file.

On the one hand, we have considered the requirements of Alice to protect her private information and on the other hand, we have considered the requirements of Bob to identify Alice in case she acts inappropriately.

In the next section, we introduce the MAPI Framework, which identifies the solutions required by an Information System in order to avoid the cases listed in this section.

4 MAPI Framework

The framework takes into consideration the concerns of Alice and Bob mentioned in Section 3 as well as the nature of the service in which Alice and Bob participate. In order to have an IS which manages or avoids privacy incidents, the outputs of the MAPI framework are the characteristics it requires.

In the next subsection, we identify the solutions that Alice and Bob require from the information system in order to allay their concerns about the possible privacy

incidents that may occur.

4.1 Required Solutions from a MAPI Information System

The following solutions for each of the cases presented in Section 3 are proposed in a MAPI Information System in order to allay the concerns of Alice and Bob about potential privacy incidents. The solutions 1-5 are required by Alice, and the solutions 6 and 7 are required by Bob. Solution 1 refers to Case 1; solutions 2a and 2b refer to Case 2 and so on.

Solution 1: She can protect her revealed private information by using encryption. She needs to protect her revealed private information while she is sending private information either to a trusted or non-trusted entity.

Solution 2a: She can prevent Bob from distributing her private information to other entities.

Solution 2b: She can detect whether Bob has revealed the private information of Alice to other entities and gather evidence about the action of Bob in order to accuse him.

Solution 3: She can use Privacy Enhancing Technologies which focus at the communication layer and can achieve anonymity and unlinkability.

For Case 4, Alice needs at least one of the following solutions (4a or 4b):

Solution 4a: Bob may permit Alice to modify her private information.

Solution 4b: Bob may provide evidence to Alice that Bob does not permit her to modify her own private information. Alice may use the evidence in court.

For Case 5, Alice needs both solutions 5a and 5b:

Solution 5a: Once Bob accepts the information from Alice, Bob is obligated to reveal the translated private information to Alice. Otherwise, Alice will have evidence that Bob denies revealing her private information.

Solution 5b: Alice can detect that the information that Alice gave to Bob and the translated private information that Bob returned to Alice are not compatible.

In both of the cases 6 and 7, where Bob is vulnerable to a privacy incident, Bob needs not only to identify Alice but also to have evidence about her actions in order to accuse her. Therefore, the required solutions of Bob are:

Solution 6a: He can identify Alice.

Solution 6b: He can gather evidence about Alice's actions.

Solution 6c: He can provide evidence that Alice's actions violate an agreement/legislation.

Solution 6d: A law exists to punish Alice.

In the next section, we group the expected solutions of Alice and Bob into some components.

4.2 Grouping the Solutions into Components

We group the required solutions of Alice and Bob into the components described in the next subsection as described in Table 1. In order to apply any solution, we need at least one of the following components.

Table 1 – The table illustrates which components are needed in order to fulfilled the requirements of each solution

Solution	Required Component
3	Privacy Communication Protocol
3	Privacy Information Flow
1, 3	Secure Communication Protocol
2b, 4a, 5a	Privacy Agreement or Legislation
2a, 2b, 4a, 4b, 5a, 5b	Privacy Information Management
2b, 4b, 5b, 6d	Accountability Agreement/Legislation
6a, 6b, 6c	Forensics
6c	Identity Revocation Agreement

4.3 The Components of the MAPI Framework

In this section, we describe in detail the components needed by a MAPI IS in order to manage or avoid all the identified potential privacy incidents that may occur to Alice and Bob as described in Section 3. The characteristics of a component define the offered functionalities or methods of the desired technology or rules.

4.3.1 Private Communication Protocol

Requirement: A private communication protocol allows a client to hide any relation (at the communication layer) that the client has with the server. The private communication protocol should offer to the client anonymity and unlinkability at the communication layer.

This component focuses at the communication layer and prevents non-trusted entities from breaking the client's anonymity and unlinkability. An example of a technology which focus to that component is the TOR [14]. However, privacy information flow should not only hide just some of the private information from a non-trusted server, but all of it. Many technologies offering communication anonymity to the client do

not hide all the private information, but may reveal information such as the email address or the credit card details of the client.

4.3.2 Privacy Information Flow

This refers to the flow of private information only to trusted entities.

Requirement: In privacy information flow, the user does not reveal any private information to non-trusted entities.

In privacy information flow, when a client needs to reveal private information to a non-trusted server, a third entity is involved. The third entity must be trusted, at least, by the client. In case the server is vulnerable to the client, the server needs to trust the third entity as well. In contrast with the private communication protocol, the privacy information flow component focuses at the application layer.

The client reveals the private information to that third entity and the third entity passes on the revealed information to the server in such a way that the server does not have access to the private information of the client.

4.3.3 Secure Communication Protocol

Privacy information cannot flow appropriately without a communication protocol.

Requirement: A secure communication protocol - any communication protocol used by the client and the server in order to offer confidentiality and integrity to the private information of the client from unauthorised entities during the data transmission.

An appropriate secure communication protocol can prevent an eavesdropper from accessing the exchanged private information or from modifying the exchanged message without detection. Examples of a secure communication protocol component are the SSL and SSH protocols.

4.3.4 Privacy Agreement or Legislation

A privacy agreement or privacy legislation is the component which allows the client and the server to agree on how the server should handle the private information of the client. In addition, it allows the client to define what is considered to be private information.

We look at the privacy policy from two points of view: The "individual's privacy policy" and the "privacy policy of a foreign party". These two privacy policies arise every time someone (an individual or a foreign party) needs to send or receive private information.

An "individual's privacy policy" (IPP) defines how the private information of that individual (which owns the private information), should be handled by others in order that his privacy not be violated.

The "privacy policy of a foreign party" (PPF) (examples of a foreign party could be a society, a government or a company) defines "how" that party handles the private information of others.

The majority of sites which offer e-commerce advertise their privacy policy (PPF). Despite the fact that a purchaser rarely reads it and the advertiser may not follow it, in some countries, the company is obligated by law to make the privacy policy available to a potential purchaser. Technologies such as P3P [11] allow the purchaser to check

automatically whether the privacy policy of the purchaser complies with the privacy policy of a web site.

A privacy agreement is necessary for every client-server communication because the privacy of a user is subjective and varies from client to client and from server to server. The privacy agreement or legislation component should:

- 1) allow Alice to prove that Bob agreed to follow the specific agreement.
- 2) state clearly the agreed privacy policy.
- 3) prevent Bob from modifying the agreed privacy policy without detection after Alice has revealed any information to him.
- 4) correlate the agreement/legislation with the exchanged messages of the communication session about which the agreement was made.

Examples of technologies which have the same aim as this component are EPAL[3] and P3P[11]. However, neither of them are capable of meeting any of these four requirements.

4.3.5 Privacy Information Management

Privacy information management requires a mechanism or technology responsible for enforcing the privacy agreement or legislation.

Technologies such as E-P3P [4] help organizations to manage appropriately the private information of customers without accidentally misusing it. However, it is up to the organization to manage appropriately the customers' private information. This component is necessary because the privacy agreement/legislation does not guarantee that the server will respect the agreement/legislation.

We identify two private information management levels which are acceptable in a MAPI Framework.

- It can prevent a non-trusted entity from misusing the private information of others. It is assumed that a non-trusted entity has access to the private information of others.
- It cannot prevent a non-trusted entity from misusing the private information of others, but it can detect and provide evidence about the malicious action of that entity.

There are mechanisms that can help to prevent the misuse of the private information of others, even though they are not compatible with the MAPI Framework.

- Although a non-trusted entity can misuse the private information of a user, a user can detect a malicious action of that non-trusted entity. For example, Alice generates a new email address (e.g. alice10@mycompany.com) and reveals it to Bob's web site. Alice and Bob agree that Bob will not reveal her email to anybody. Alice does not reveal this email to anybody else. If she receives an email to this address from someone else, she can conclude that Bob violated their agreement. Although Alice knows that Bob violated their agreement, she cannot prove it to others.
- An entity establishes an appropriate technique to avoid accidentally misusing the private information of users.

4.3.6 Forensics

The Forensics component has a set of requirements. A technology that is compatible

with the forensics component should meet the following four requirements:

Requirement R1: identify Alice without affecting negatively other entities (e.g. violating the privacy or others)

Requirement R2: gather evidence about the actions of Alice according to the Accountability Legislation or Agreement.

Requirement R3: handle the evidence according to the Accountability Legislation or Agreement, in order to be submittable in a court.

Requirement R4: prevent Alice (as well as anybody else), from causing the Forensics component to malfunction and from meeting the above three requirements.

The Forensics component should begin functioning only in case the Identity Revocation Agreement is met. This is described in the next section.

4.3.7 Identity Revocation Agreement

An Identity Revocation Agreement states the cases under which Bob has the right to identify and accuse Alice.

Requirement: An identity revocation agreement should include a technique whereby the participating entities should not be able to deny that they both agree to the specific identity revocation agreement and no one should be able to modify the identity revocation agreement without detection after they have agreed to it.

Currently, there is no technology available that enforces an identity revocation agreement. However, privacy agreement technologies could be extended in order to include an identity revocation agreement. It is a very important component for a MAPI technology. The entity responsible for deciding whether the identity revocation agreement has been met should be trusted and acceptable to the participating entities.

4.3.8 Accountability agreement or legislation

All developed countries have legislation (e.g. [15, 19]) which describes what the characteristics of evidence in the digital era are. Although the legislation is different from country to country, there are some similarities. This component is most critical when a client and a server are located in different countries.

Requirement: This component should provide a guarantee to the participants that in case the privacy agreement/legislation is violated or the identity revocation agreement is satisfied, the dishonest entities are going to face a penalty.

Evidence that shows the involvement of Alice should offer non-repudiation to the actions of Alice. An example of that is a document signed by the private key of her.

Not all the described components are necessary for every MAPI IS. In the next section, we identify the required components for a MAPI technology based on the characteristics of the technology.

4.4 Needed Components for a MAPI Information System

There are technologies which protect the private information of a client in a client-server architecture. In order for a technology to be considered as one which offers privacy and is also able to manage or avoid privacy incidents, it needs to enhance some components (in a case-based situation). If we know which components are

needed, then we can develop mechanisms or technologies which achieve the characteristics of one or more of these components. In this case, we can also achieve a level of collaboration among the components and technologies within a MAPI IS. An example is the ERPINA protocol [2] which does not offer anonymity itself but which has been designed to be integrated with any PET technology offering communication anonymity to the client, while it can also support the P3P protocol (or any related protocol). We present a diagram (Figure 2), which shows the required components for an IS which offers privacy to honest clients and accountability to dishonest clients or server.

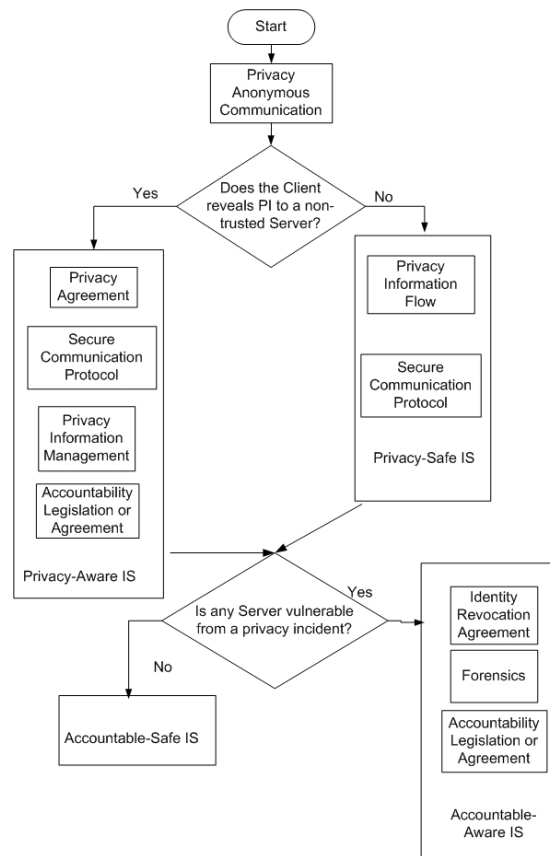


Figure 2 - Framework for developing MAPI Information Systems

In a privacy-aware technology, although a client reveals private information to a server, the client does not need to trust that a server will handle the private information of the client based on the privacy agreement. An IS in which the client and the server are not a threat to each other is referred to as a Free-Of-Privacy Incident IS; this situation is desirable for all participating entities.

Having an identity revocation agreement in place helps a participating trusted entity to take an objective decision to revoke the right to privacy of a malicious user or not. However, there is no current technology focusing on this component; existing

technologies [1, 10, 13, 17, 18] allow the trusted entity to take a subjective decision whether or not to reveal the private information of the user.

4.4.1 Privacy Agreement and Identity Revocation Agreement

In case the client reveals private information to the server, a privacy agreement/legislation is needed because the client is vulnerable to the server. A privacy agreement/legislation forces the server to act responsibly. If the server is not a potential threat to the client (that is, if no private information has been revealed to that server), no privacy agreement/legislation is necessary.

An example of privacy legislation is the legislation that obligates an employer to inform an employee before monitoring his activities (movements in a building, emails, telephone calls, etc). An example of a privacy agreement is a privacy policy that a company advertises before revealing private information to a web site.

Without a privacy agreement/legislation, privacy information management is not necessary because either Bob has no private information to manage or there is no restriction on how Bob can use the information provided by Alice.

We have three scenarios for describing the possible combinations of the need for a privacy and revocation agreement. In all three scenarios, Alice represents the client and Bob the server:

- Scenario 1: Alice wants to protect her identity, but Bob wants to have a forensic mechanism in order to identify her in case of an attack. We need a kind of agreement, an “Identity Revocation Agreement”, which states under what conditions Bob has the right to identify and accuse Alice. In this case, the agreement exists to protect Bob from malicious actions of Alice.
- Scenario 2: Alice reveals private information to Bob, and Bob misuses her private information. Since Bob knows the private information of Alice, we do not need an “Identity Revocation Agreement”. Instead we need a “Privacy Information Agreement” which states how Bob should handle her private information. The agreement exists to protect Alice from malicious actions of Bob.
- Scenario 3: Alice wants to hide her private information from Bob. Alice cannot harm Bob. Since Alice cannot harm Bob and Bob cannot violate the privacy information of Alice, there is no need to have an identity revocation agreement or privacy information agreement. This scenario describes a free-of-privacy incident technology.

5. Conclusion

This work builds the foundation for designing information systems which can manage or avoid privacy incidents. In addition, this paper identifies the need for techniques for identity revocation and suggests a way to fill the gap. This paper also studies the privacy concerns of a client, breaking them down into three major security objectives: Confidentiality, Integrity and Availability, and supplies technology solutions which ensure their preservation. In future work, we will use the MAPI framework to evaluate existing technologies and identify those components which they lack in order to comply with a complete MAPI information system.

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