# Anonymity, Unlinkability, Unobservability, Pseudonymity, and Identity Management – A Consolidated Proposal for Terminology

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Andreas Pfitzmann
TU Dresden
pfitza@inf.tu-dresden.de

Marit Hansen
ULD Kiel
marit.hansen@datenschutzzentrum.de

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### Abstract

Based on the nomenclature of the early papers in the field, we propose a terminology which is both expressive and precise. More particularly, we define *anonymity*, *unlinkability*, *unobservability*, *pseudonymity* (*pseudonyms* and *digital pseudonyms*, and their attributes), and *identity management*. In addition, we describe the relationships between these terms, give a rational why we define them as we do, and sketch the main mechanisms to provide for the properties defined.

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**List of abbreviations**

| | |
|---|---|
| DC-net | Dining Cryptographers network |
| iff | if and only if |
| IHW | Information Hiding Workshop |
| IMS | Identity Management System |
| IOI | Item Of Interest |
| ISO | International Standardization Organization |
| MMORPG | Massively Multiplayer Online Role Playing Games |
| MUD | Multi User Dungeon |
| PE-IMS | Privacy-Enhancing Identity Management System |
| PETs | Privacy-Enhancing Technologies |
| PGP | Pretty Good Privacy |

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## 1 Introduction

Early papers from the 1980ies already deal with anonymity, unlinkability, unobservability, and pseudonymity and introduce these terms within the respective context of proposed measures. We show relationships between these terms and thereby develop a consistent terminology. Then we contrast these definitions with newer approaches, e.g., from ISO IS 15408. After decades of research on mechanisms for anonymity, unlinkability, unobservability and pseudonymity and many years of development and broad discussion of this terminology, this part of the terminology can be considered as consolidated. Finally, we extend this terminology to identity management. Identity management is a much younger and much less defined field – so a really consolidated proposal for terminology for this field does not exist. But nevertheless, after development and broad discussion since 2004, this terminology is the most consolidated one in this rapidly emerging field.

We hope that the adoption of this terminology might help to achieve better progress in the field by avoiding that each researcher invents a language of his/her own from scratch. Of course, each paper will need additional vocabulary, which might be added consistently to the terms defined here.

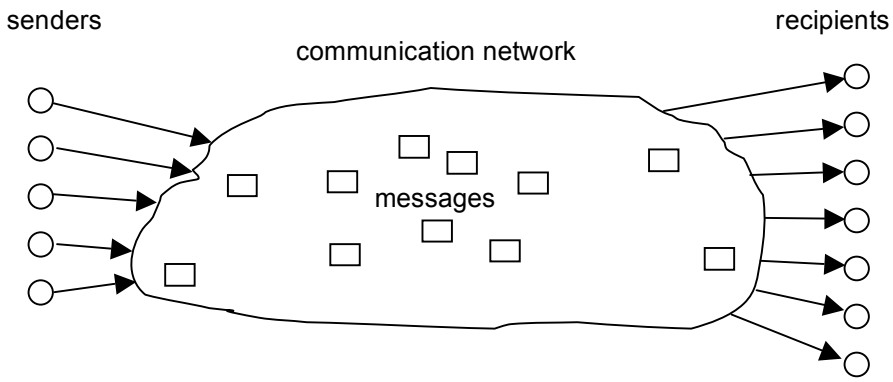
This document is organized as follows: First the setting used is described. Then definitions of anonymity, unlinkability, and unobservability are given and the relationships between the respective terms are outlined. Afterwards, known mechanisms to achieve anonymity and unobservability are listed. The next sections deal with pseudonymity, i.e., pseudonyms, their properties, and the corresponding mechanisms. Thereafter, this is applied to privacy-enhancing identity management. Finally, concluding remarks are given. To make the document readable to as large an audience as possible, we did put information which can be skipped in a first reading or which is only useful to part of our readership, e.g. those knowing information theory, in footnotes.

## 2 Setting

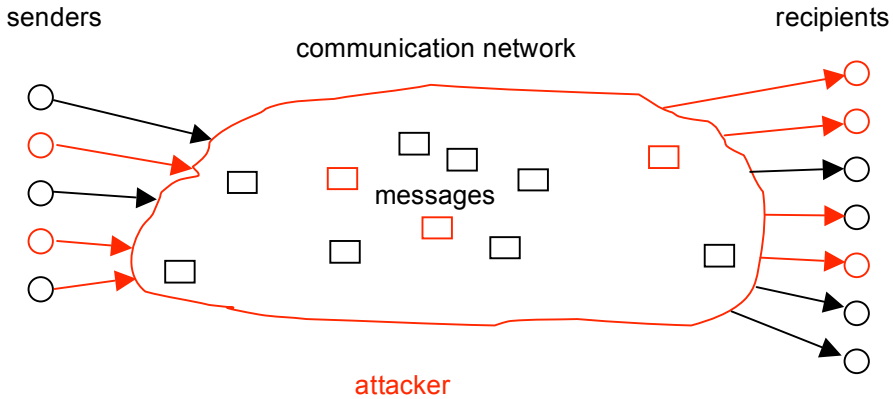
We develop this terminology in the usual setting that *senders* send *messages* to *recipients* using a communication network. For other settings, e.g., users querying a database, customers shopping in an e-commerce shop, the same terminology can be derived by abstracting away the special names “sender”, “recipient”, and “message”. But for ease of explanation, we use the specific setting here.

If we make our setting more concrete, we may call it a *system*. For our purposes, a system has the following relevant properties:

1. The system has a surrounding, i.e. parts of the world are “outside” the system. Together, the system and its surrounding form the universe.
2. The state of the system may change by actions within the system.




All statements are made from the perspective of an *attacker*[1] who may be interested in monitoring what communication is occurring, what patterns of communication exist, or even in manipulating the communication. We not only assume that the attacker may be an outsider[2] tapping communication lines, but also an insider[3] able to participate in normal communications and controlling at least some stations. We assume that the attacker uses all facts available to him to infer (probabilities of) his *items of interest* (IOIs), e.g. who did send or receive which messages.




Throughout the Sections 3 to 12 we assume that the attacker is not able to get information on the sender or recipient from the message content.[4] Therefore, we do not mention the message content in these sections. For most applications it is unreasonable to assume that the attacker forgets something. Thus, normally the knowledge[5] of the attacker only increases.

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[1] In the sequel, this leads to a wording like "<Property x> is the state of ..." which is clearly no "state" in an absolute, self-contained sense, but a state depending on the attacker's perspective, i.e., the information the attacker has available. If we assume some limits on how much processing the attacker might be able to do, the information available to the attacker will not only depend on the attacker's perspective, but on the attacker's processing (abilities), too.

[2] An outsider is a non-empty set of entities being part of the surrounding of the system considered.

[3] An insider is a non-empty set of entities being part of the system considered.

[4] Of course, encryption of messages provides protection of the content against attackers observing the communication lines and end-to-end encryption even provides protection of the content against all stations passed, e.g. for the purpose of forwarding and/or routing. But message content can neither be hidden from the sender nor from the recipient(s) of the message.

[5] As usual in the field of security and privacy, "knowledge" can be described by probabilities of IOIs. More knowledge then means more accurate probabilities, i.e. the probabilities the attacker assumes to be true are closer to the "true" probabilities.

## 3 Anonymity

To enable anonymity of a subject[6], there always has to be an appropriate set of subjects with potentially the same attributes[7].

***Anonymity* is the state of being not identifiable[8] within a set of subjects, the *anonymity set*.**[9]

The *anonymity set* is the set of all possible subjects[10]. With respect to acting entities, the anonymity set consists of the subjects who might cause an action. With respect to addressees[11], the anonymity set consists of the subjects who might be addressed. Therefore, a sender may be anonymous only within a set of potential senders, his/her *sender anonymity set*, which itself may be a subset of all subjects worldwide who may send messages from time to time. The same is true for the recipient, who may be anonymous within a set of potential recipients, which form his/her *recipient anonymity set*. Both anonymity sets may be disjoint, be the same, or they may overlap. The anonymity sets may vary over time.[12]

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[6] A *subject* is a possibly acting entity such as, e.g., a human being (i.e. a natural person), a legal person, or a computer. (An organization not acting as a legal person we neither see as a single subject nor as a single entity, but as (possibly structured) sets of subjects or entities. Otherwise, the distinction between “subjects” and “sets of subjects” would completely blur. But we need that distinction in Section 9 e.g. to sensibly define group pseudonyms.)

[7] Since sending and receiving of particular messages are special cases of "attributes" of senders and recipients, this is slightly more general than the setting in Section 2. This generality is very fortunate to stay close to the everyday meaning of "anonymity" which is not only used w.r.t. subjects active in a particular context, e.g. senders and recipients of messages, but to subjects passive in a particular context as well, e.g. subjects the records within a database relate to.

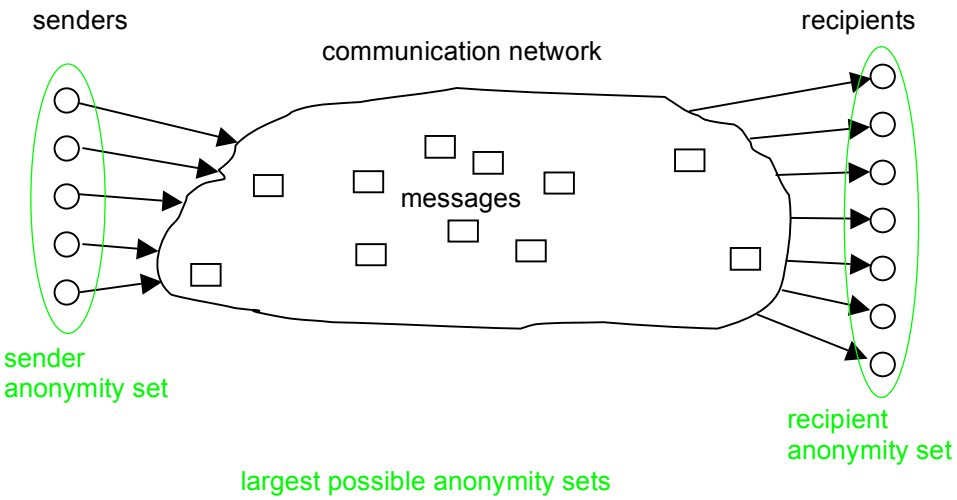
[8] “not identifiable within” means “not uniquely characterized within”.

[9] From [ISO99]: “[Anonymity] ensures that a user may use a resource or service without disclosing the user’s identity. The requirements for anonymity provide protection of the user identity. Anonymity is not intended to protect the subject identity. [...] Anonymity requires that other users or subjects are unable to determine the identity of a user bound to a subject or operation.” Compared with this explanation, our definition is more general as it is not restricted to identifying users, but any subjects.

[10] I.e., the “usual suspects” :-) The set of possible subjects depends on the knowledge of the attacker. Thus, anonymity is relative with respect to the attacker.

[11] Addressees are subjects being addressed.

[12] Since we assume that the attacker does not forget anything he knows, the anonymity set cannot increase w.r.t. a particular action. Especially subjects joining the system in a later stage, do not belong to the anonymity set from the point of view of an attacker observing the system in an earlier stage. (Please note that if the attacker cannot decide whether the joining subjects were present earlier, the anonymity set does not increase either: It just stays the same.) Due to linkability, cf. below, the anonymity set normally can only decrease.

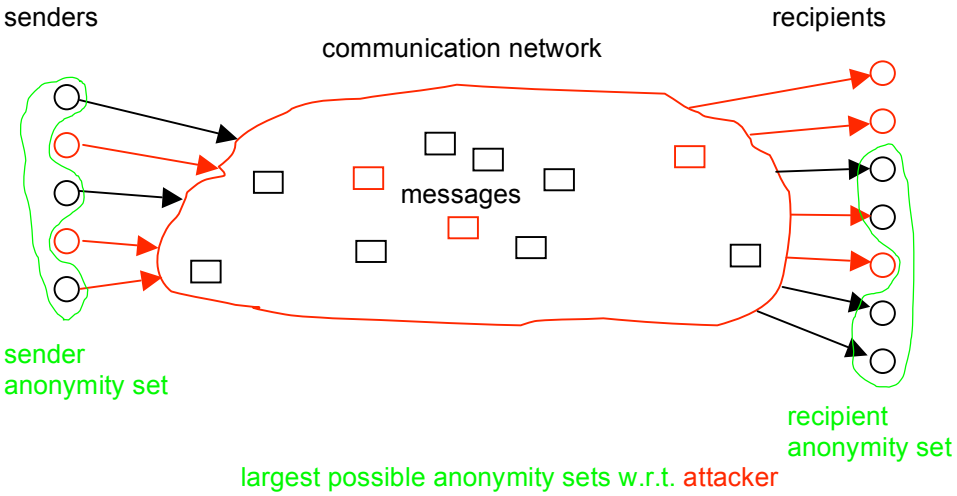



All other things being equal, anonymity is the stronger, the larger the respective anonymity set is and the more evenly distributed the sending or receiving, respectively, of the subjects within that set is.[13,14]

From the above discussion follows that anonymity in general as well as the anonymity of each particular subject is a concept which is very much context dependent (on, e.g., subjects population, attributes, time frame, etc). In order to quantify anonymity within concrete situations, one would have to describe the system in sufficient detail which is practically not (always) possible for large open systems (but maybe for some small data bases for instance). Besides the *quantity of anonymity* provided within a particular setting, there is another aspect of anonymity: its robustness. *Robustness of anonymity* characterizes how stable the quantity of anonymity is against changes in the particular setting, e.g. a stronger attacker or different probability distributions. We might use *quality of anonymity* as a term comprising both quantity and robustness of anonymity. To keep this text as simple as possible, we will mainly discuss the quantity of anonymity in the sequel, using the wording “strength of anonymity”.

[13] The entropy of a message source as defined by Claude E. Shannon [Shan48] might be an appropriate measure to quantify anonymity – just take who is the sender/recipient as the “message” in Shannon’s definition. For readers interested in formalizing what we informally say: “No change of probabilities” means “no change of knowledge” and vice versa. “No change of probabilities” (or what is equivalent: “no change of knowledge”) implies “no change of entropy”, whereas “no change of entropy” neither implies “no change of probabilities” nor “no change of knowledge”. In an easy to remember notation: No change of probabilities = no change of knowledge ⇒ no change of entropy.

[14] One might differentiate between the term anonymity and the term indistinguishability, which is the state of being indistinguishable from other elements of a set. Indistinguishability is stronger than anonymity as defined in this text. Even against outside attackers, indistinguishability does not seem to be achievable without dummy traffic. Against recipients of messages, it does not seem to be achievable at all. Therefore, the authors see a greater practical relevance in defining anonymity independent of indistinguishability. The definition of anonymity is an analog to the definition of “perfect secrecy” by Claude E. Shannon [Shan49], whose definition takes into account that no security mechanism whatsoever can take away knowledge from the attacker which he already has.




## 4 Unlinkability

Unlinkability only has a meaning after the system in which we want to describe anonymity, unobservability, or pseudonymity properties has been defined and the entities interested in linking (the attacker) have been characterized. Then:

***Unlinkability* of two or more items of interest (IOIs, e.g., subjects, messages, actions, ...) means that within the system (comprising these and possibly other items), from the attacker's perspective, these items of interest are no more and no less related after his observation than they are related concerning his a-priori knowledge.**[15,16]

This means that the probability of those items being related from the attacker's perspective stays the same before (a-priori knowledge) and after the attacker's observation (a-posteriori knowledge of the attacker).[17,18]

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[15] From [ISO99]: "[Unlinkability] ensures that a user may make multiple uses of resources or services without others being able to link these uses together. [...] Unlinkability requires that users and/or subjects are unable to determine whether the same user caused certain specific operations in the system." In contrast to this definition, the meaning of unlinkability in this text is less focused on the user, but deals with unlinkability of "items" and therefore is a general approach. Note that we chose a relative definition of unlinkability, referring to a-priori knowledge and its possible change. We may differentiate between "absolute unlinkability" (as in [ISO99]; i.e., "no determination of a link between uses") and "relative unlinkability" (i.e., "no change of knowledge about a link between uses").

[16] As the entropy of a message source might be an appropriate measure to quantify anonymity (and thereafter "anonymity" might be used as a quantity), we may use definitions to quantify unlinkability (and thereafter "unlinkability" might be used as a quantity as well). Quantifications of unlinkability can be either probabilities or entropies, or whatever is useful in a particular context.

[17] Normally, the attacker's knowledge cannot decrease (analogously to Shannon's definition of "perfect secrecy", see above). An exception of this rule is the scenario where the use of *misinformation* (inaccurate or erroneous information, provided usually without conscious effort at misleading, deceiving, or persuading one way or another [Wils93]) or *disinformation* (deliberately false or distorted information given out in order to mislead or deceive [Wils93]) leads to a growing uncertainty of the attacker which information is correct. In the special case where it is known before that some items are related, of course the probability of these items being related stays the same. Even in this "degenerated" case it makes sense to use the term unlinkability because there is no *additional* information. A related, but different aspect is that information may become

E.g., two messages are unlinkable for an attacker if the a-posteriori probability describing his a-posteriori knowledge that these two messages are sent by the same sender and/or received by the same recipient is the same as the probability imposed by his a-priori knowledge.[19]

Roughly speaking, unlinkability of items means that the ability of the attacker to relate these items does not increase by observing the system.

## 5 Anonymity in terms of unlinkability

If we consider sending and receiving of messages as the items of interest (IOIs)[20], *anonymity* may be defined as unlinkability of an IOI and any subject. More specifically, we can describe the anonymity of an IOI such that it is not linkable to any subject, and the anonymity of a subject as not being linkable to any IOI.[21]

So we have *sender anonymity* as the properties that a particular message is not linkable to any sender and that to a particular sender, no message is linkable.

The same is true concerning *recipient anonymity*, which signifies that a particular message cannot be linked to any recipient and that to a particular recipient, no message is linkable.

*Relationship anonymity* means that it is untraceable who communicates with whom. In other words, sender and recipient (or recipients in case of multicast) are unlinkable. Thus, relationship anonymity is a weaker[22] property than each of sender anonymity and recipient anonymity: It may

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wrong (i.e., outdated) simply because the state of the world changes over time. Since data protection is not only about to protect the current state, but the past and history of a data subject as well, we will not make use of this different aspect in the rest of this paper.

[18] In some publications, the a-priori knowledge of the attacker is called “background knowledge” and the a-posteriori knowledge of the attacker is called “new knowledge”.

[19] Please note that unlinkability of two (or more) messages of course may depend on whether their content is protected against the attacker considered. In particular, messages may be unlinkable if we assume that the attacker is not able to get information on the sender or recipient from the message content, cf. Section 2. Yet with access to their content even without deep semantical analysis the attacker can notice certain characteristics which link them together – e.g. similarities in structure, style, use of some words or phrases, consistent appearance of some grammatical errors, etc. In a sense, content of messages may play a role as “side channel” in a similar way as in cryptanalysis – i.e. content of messages may leak some information on their linkability.

[20] The general term IOI is chosen in order to be able to more easily extend the meaning in later sections, e.g., including communication relationships.

[21] Unlinkability is a sufficient condition of anonymity (since we defined anonymity in absolute terms, i.e., not relative to the a-priori knowledge of an attacker, but unlinkability only relative to the a-priori knowledge of the attacker, this is not exactly true, but it would be if we either made the definition of unlinkability stronger or the definition of anonymity weaker), but it is not a necessary condition. Thus, failing unlinkability does not necessarily eliminate anonymity as defined in Section 3; in specific cases even the strength of anonymity may not be affected.

[22] First the easy direction: For all attackers it holds: Sender anonymity implies relationship anonymity, and recipient anonymity implies relationship anonymity. Then the more complicated direction: There exists at least one attacker model, where relationship anonymity does neither imply sender anonymity nor recipient anonymity. Consider an attacker who neither controls any senders nor any recipients of messages, but all lines and – may be – some other stations. If w.r.t. this attacker relationship anonymity holds, you can neither argue that against him sender anonymity holds nor tm recipient anonymity holds. The classical MIX-net (cf. Section 8) without dummy traffic is one implementation with just this property: The attacker sees who sends

be traceable who sends which messages and it may also be possible to trace who receives which messages, as long as there is no linkability between any message sent and any message received and therefore the relationship between sender and recipient is not known. The *relationship anonymity set* can be defined to be the cross product of two potentially distinct sets, the set of potential senders and the set of potential recipients[23]. So the relationship anonymity set is the set of all possible sender-recipient(s)-pairs.[24] If we take the perspective of a subject sending (or receiving) a particular message, the relationship anonymity set becomes the set of all potential recipients (senders) of that particular message. So fixing one factor of the cross product gives a recipient anonymity set or a sender anonymity set.

## 6 Undetectability and unobservability

In contrast to anonymity and unlinkability, where not the IOI, but only its relationship to subjects or other IOIs is protected, for undetectability, the IOIs are protected as such.[25]

***Undetectability* of items of interest (IOIs) is the state that whether they exist or not is indistinguishable**[26,27]

This means that messages are not discernible from e.g. “random noise”.[28]

Undetectability of IOIs clearly is only possible w.r.t. subjects being not related to any particular IOI (e.g. neither being the sender nor one of the recipients of a message). Therefore, if we just speak about undetectability without spelling out the set of IOIs, it goes without saying that this is a statement comprising only those IOIs the attacker is not related to.

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messages when and who receives messages when, but cannot figure out who sends messages to whom.

[23] In case of multicast, the set of potential recipients is the power set of all potential recipients.

[24] For measures to quantify relationship anonymity, if they shall be comparable with quantifying sender and recipient anonymity, you have to compensate for the multiplication of possibilities in forming the cross product. For the simplest metric (we do not advocate to use) just counting the size of the set, you have to take the square root of the size of the set of possible sender-recipient(s)-pairs.

[25] Undetectability can be regarded as a possible and desirable property of steganographic systems (see Section 8 “Known mechanisms for anonymity, undetectability, and unobservability”). Therefore it matches the information hiding terminology [Pfit96, ZFKP98]. In contrast, anonymity, dealing with the relationship of discernible IOIs to *subjects*, does not directly fit into that terminology, but independently represents a different dimension of properties.

[26] What we call “undetectability” starting with Version v0.28 of this document, has been called “unobservability” before. From [ISO99]: “[Unobservability] ensures that a user may use a resource or service without others, especially third parties, being able to observe that the resource or service is being used. [...] Unobservability requires that users and/or subjects cannot determine whether an operation is being performed.” As seen before, our approach is less user-focused and insofar more general. With the communication setting and the attacker model chosen in this text, our definition of unobservability shows the method how to achieve it: preventing distinguishability of IOIs. Thus, the ISO definition might be applied to a different setting where attackers are prevented from observation by other means, e.g., by encapsulating the area of interest against third parties.

[27] In some applications (e.g. steganography), it might be useful to quantify undetectability to have some measure how much uncertainty about an IOI remains after the attacker’s observations. Again, we may use probabilities or entropy, or whatever is useful in a particular context.

[28] A slightly more precise formulation might be that messages are not discernible from no message. A quantification of this property might measure the number of indistinguishable IOIs and/or the probabilities of distinguishing these IOIs.

As the definition of undetectability stands, it has nothing to do with anonymity – it does not mention any relationship between "could be" IOIs and subjects causing them. Even more, for subjects being related to an IOI, undetectability of this IOI is clearly impossible. Therefore, early papers describing new mechanisms for undetectability designed the mechanisms in a way that if a subject necessarily could detect an IOI, the other subject(s) related to that IOI enjoyed anonymity at least. Undetectability by unrelated subjects together with anonymity even if IOIs can be detected has been called unobservability:

***Unobservability* of items of interest (IOIs) is the state that**

- **whether they exist or not is indistinguishable by all subjects unrelated to the "could be" IOIs and of**
- **anonymity of the other subject(s) related to an IOI even against the other subject(s) related to that IOI.**

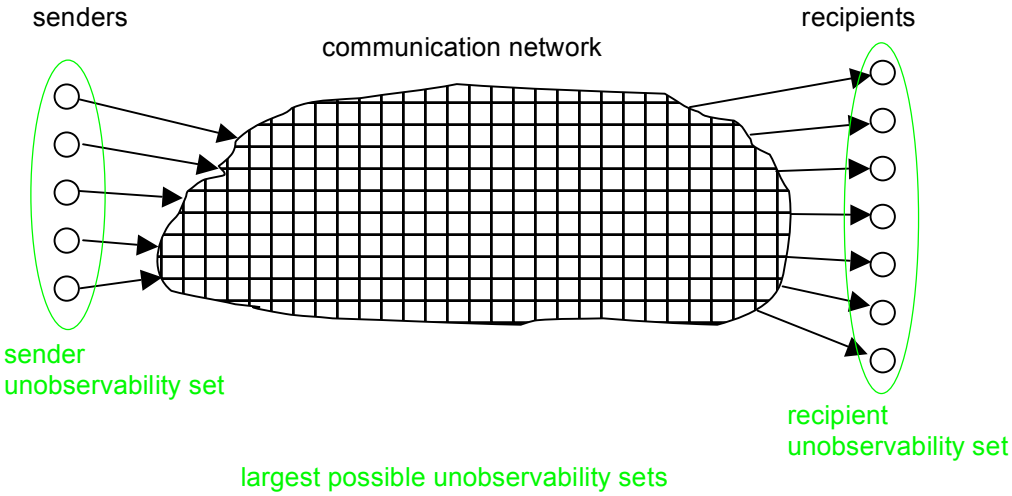
As we had anonymity sets of subjects with respect to anonymity, we have *unobservability sets* of subjects with respect to unobservability.[29]

*Sender unobservability* then means that it is not detectable whether any sender within the unobservability set sends.

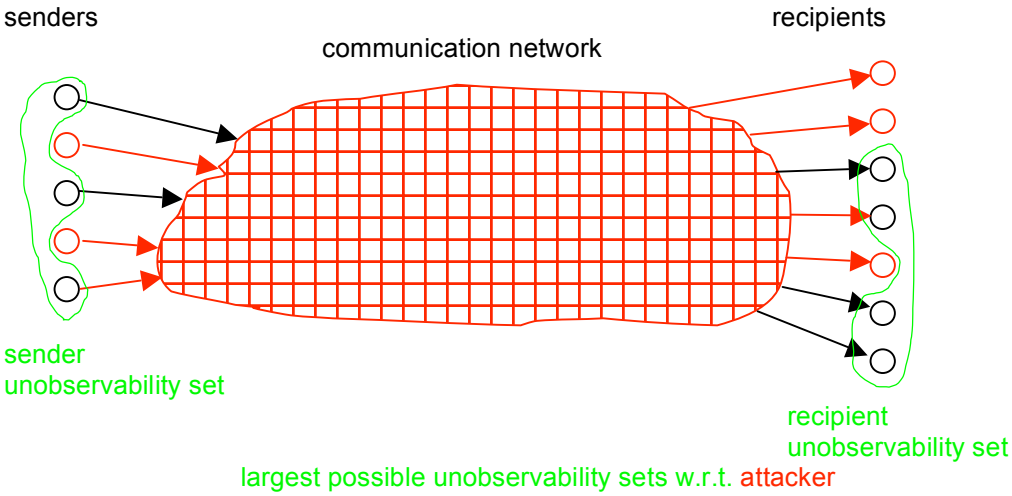
*Recipient unobservability* then means that it is not detectable whether any recipient within the unobservability set receives.

*Relationship unobservability* then means that it is not detectable whether anything is sent out of a set of could-be senders to a set of could-be recipients. In other words, it is not detectable whether within the relationship unobservability set of all possible sender-recipient(s)-pairs, a message is exchanged in any relationship.

All other things being equal, unobservability is the stronger, the larger the respective unobservability set is.




[29] Mainly, unobservability deals with IOIs instead of subjects only. Though, like anonymity sets, unobservability sets consist of all subjects who might possibly cause these IOIs, i.e. send and/or receive messages.




**7 Relationships between terms**

With respect to the same attacker, unobservability reveals always only a subset of the information anonymity reveals.[30] We might use the shorthand notation

unobservability ⇒ anonymity

for that (⇒ reads “implies”). Using the same argument and notation, we have

sender unobservability ⇒ sender anonymity
recipient unobservability ⇒ recipient anonymity
relationship unobservability ⇒ relationship anonymity

As noted above, we have

sender anonymity ⇒ relationship anonymity
recipient anonymity ⇒ relationship anonymity

sender unobservability ⇒ relationship unobservability
recipient unobservability ⇒ relationship unobservability

With respect to the same attacker, unobservability reveals always only a subset of the information undetectability reveals

unobservability ⇒ undetectability

[30] [ReRu98] propose a continuum for describing the strength of anonymity with the following states named: “absolute privacy” (the attacker cannot perceive the presence of communication, i.e., unobservability) – “beyond suspicion” – “probable innocence” – “possible innocence” – “exposed” – “provably exposed” (the attacker can prove the sender, recipient, or their relationship to others). Although we think that the terms “privacy” and “innocence” are misleading, the spectrum is quite useful.

## 8 Known mechanisms for anonymity, undetectability, and unobservability

Before it makes sense to speak about any particular mechanisms for anonymity, undetectability, and unobservability in communications, let us first remark that all of them assume that stations of users do not emit signals the attacker considered is able to use for identification of stations or their behavior or even for identification of users or their behavior. So if you travel around taking with you a mobile phone sending more or less continuously signals to update its location information within a cellular network, don't be surprised if you are tracked using its signals. If you use a computer emitting lots of radiation due to a lack of shielding, don't be surprised if observers using high-tech equipment know quite a bit about what's happening within your machine. If you use a computer, PDA, or smartphone without sophisticated access control, don't be surprised if Trojan horses send your secrets to anybody interested whenever you are online – or via electromagnetic emanations even if you think you are completely offline.

DC-net [Chau85, Chau88] and MIX-net [Chau81] are mechanisms to achieve sender anonymity and relationship anonymity, respectively, both against strong attackers. If we add dummy traffic, both provide for the corresponding unobservability [PfPW91].[31]

Broadcast [Chau85, PfWa86, Waid90] and private information retrieval [CoBi95] are mechanisms to achieve recipient anonymity against strong attackers. If we add dummy traffic, both provide for recipient unobservability.

This may be summarized: A mechanism to achieve some kind of anonymity appropriately combined with dummy traffic yields the corresponding kind of unobservability.

Of course, dummy traffic[32] alone can be used to make the number and/or length of sent messages undetectable by everybody except for the recipients; respectively, dummy traffic can be used to make the number and/or length of received messages undetectable by everybody except for the senders.

As a side remark, we mention steganography and spread spectrum as two other well-known undetectability mechanisms.

The usual concept to achieve undetectability of IOIs at some layer, e.g. sending meaningful messages, is to achieve statistical independence of all discernible phenomena at some lower implementation layer. An example is sending dummy messages at some lower layer to achieve e.g. a constant rate flow of messages looking – by means of encryption – randomly for all parties except the sender and the recipient(s).

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[31] If dummy traffic is used to pad sending and/or receiving on the sender's and/or recipient's line to a constant rate traffic, MIX-nets can even provide sender and/or recipient anonymity and unobservability.

[32] Misinformation and disinformation may be regarded as semantic dummy traffic, i.e., communication from which an attacker cannot decide which are real requests with real data or which are fake ones. Assuming the authenticity of misinformation or disinformation may lead to privacy problems for (innocent) bystanders.

## 9 Pseudonymity

Having anonymity of human beings, unlinkability, and maybe unobservability is superb w.r.t. data minimization, but would prevent any useful two-way communication. For two-way communication, cooperation and collaboration, we need appropriate kinds of identifiers:

**A *pseudonym* is an identifier[33] of a subject[34], in our setting of sender and recipient, other than one of the subject's real names[35].**

We can generalize pseudonyms to be identifiers of *sets* of subjects – see below –, but we do not need this in our setting. The subject which the pseudonym refers to is the *holder* of the pseudonym[36].

**A subject is *pseudonymous* if a pseudonym[37] is used[38] as identifier instead of one of its real names.[39],[40]**

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[33] Names or other bit strings.

[34] "Pseudonym" comes from Greek "pseudonumon" meaning "falsely named" (pseudo: false; onuma: name). Thus, it means a name other than the "real name". To avoid the connotation of "pseudo" = false, some authors call pseudonyms as defined in this paper simply *nyms*. This is nice and short, but we stick with the usual wording, i.e. pseudonym, pseudonymity, etc. However the reader should not be surprised to read nym, nymity, etc. in other texts.

[35] "Real name" is the antonym to pseudonym. There may be multiple real names over life time, in particular the legal names, i.e. for a human being the names which appear on the birth certificate or on other official identity documents issued by the State; for a legal person the name under which it operates and which is registered in official registers (e.g., commercial register or register of associations). A human being's real name typically comprises their given name and a family name.
Note that from a mere technological perspective it cannot always be determined whether an identifier of a subject is a pseudonym or a real name.

[36] We prefer the term "holder" over "owner" of a pseudonym because it seems to make no sense to "own" identifiers, e.g., bit strings. Furthermore, the term "holder" sounds more neutral than the term "owner", which is associated with an assumed autonomy of the subject's will. The holder may be a natural person (in this case we have the usual meaning and all data protection regulations apply), a legal person, or even only a computer.

[37] Fundamentally, pseudonyms are nothing else than another kind of attributes. But whereas in building an IT system, its designer can strongly support the holders of pseudonyms to keep the pseudonyms under their control, this is not equally possible w.r.t. attributes in general. Therefore, it is useful to give this kind of attribute a distinct name: pseudonym.

[38] For pseudonyms chosen by the user (in contrast to pseudonyms assigned to the user by others), primarily, the holder of the pseudonym is using it. Secondarily, all others he communicated the pseudonym to can utilize it for linking. Each of them can, of course, divulge the pseudonym and all data related to it to other entities. So finally, the attacker will utilize the pseudonym to link all data related to this pseudonym he gets to know being related. Hopefully, the appropriate use of pseudonyms primarily by the holder (cf. Pseudonymity w.r.t. linkability, Section 11, and Identity management, Section 13) and secondarily by others will keep the sensitivity of the linkable data sets to a minimum.

[39] We can also speak of "pseudonymous usage" (i.e. use of a pseudonym instead of the real name(s)) and of "pseudonymous data" (i.e. data belonging to a subject where a pseudonym is used instead of its real name(s)).

[40] Please note that despite the terms "anonymous" and "pseudonymous" are sharing most of their letters, their semantics is quite different: Anonymous says something about the state of a subject with respect to identifiability, pseudonymous only says something about employing a mechanism, i.e., using pseudonyms. Whether this mechanism helps in a particular setting to achieve something close to anonymity, is a completely different question. On the level of states of subjects, "anonymous" should be contrasted with "(privacy enhancingly) identity managed", cf.

Defining the process of preparing for the use of pseudonyms e.g. by establishing certain rules how and under which conditions to identify holders of pseudonyms by so-called *identity brokers*[41] or how to prevent uncovered claims by so-called *liability brokers* (cf. Section 11), leads to the more general notion of pseudonymity[42]:

***Pseudonymity* is the use of pseudonyms as identifiers.**[43,44]

So *sender pseudonymity* is defined as the sender being pseudonymous, *recipient pseudonymity* is defined as the recipient being pseudonymous.[45]

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Section 13.4. But since "anonymous" can be defined precisely whereas "(privacy enhancingly) identity managed" is at least at present hard to define equally precise, we prefer to follow the historical path of research dealing with the more precise mechanism (pseudonym, pseudonymity) first.

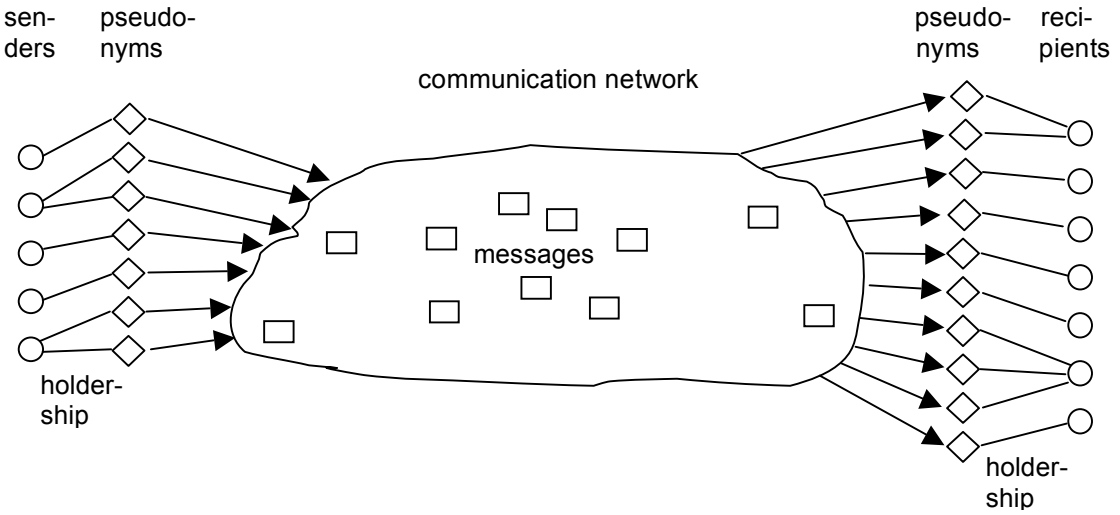
[41] *Identity brokers* have for the pseudonyms they are the identity broker for the information who is their respective holder. Therefore, identity brokers can be implemented as a special kind of certification authorities for pseudonyms. Since anonymity can be described as a particular kind of unlinkability, cf. Section 5, the concept of identity broker can be generalized to linkability broker. A *linkability broker* is a (trusted) third party that, adhering to agreed rules, enables linking IOIs for those entities being entitled to get to know the linking.

[42] Concerning the natural use of the English language, one might use "pseudonymization" instead of "pseudonymity". But at least in Germany, the data protection officers gave "pseudonymization" the meaning that you have first person-related data having some kinds of identifier for the civil identity (cf. the footnote in Section 10.2 for some clarification of "civil identity"): "replacing a person's name and other identifying characteristics with a label, in order to preclude identification of the data subject or to render such identification substantially difficult" (§ 6a German Federal Data Protection Act). Therefore, we use a different term (coined by David Chaum: "pseudonymity") to describe the process where from the very beginning, only the holder is able to link to his/her civil identity.

[43] From [ISO99]: "[Pseudonymity] ensures that a user may use a resource or service without disclosing its user identity, but can still be accountable for that use. [...] Pseudonymity requires that a set of users and/or subjects are unable to determine the identity of a user bound to a subject or operation, but that this user is still accountable for its actions." This view on pseudonymity covers only the use of digital pseudonyms. Therefore, our definition of pseudonymity is much broader as it does not necessarily require disclosure of the user's identity and accountability. Pseudonymity alone – as it is used in the real world and in technological contexts – does not tell anything about the strengths of anonymity, authentication or accountability; these strengths depend on several properties, cf. below.

[44] Quantifying pseudonymity would primarily mean quantifying the state of using a pseudonym according to its different dimensions (cf. the next two Sections 10 and 11), i.e., quantifying the authentication and accountability gained and quantifying the anonymity left over (e.g. using entropy as the measure). Roughly speaking, well-employed pseudonymity would mean appropriately fine-grained authentication and accountability to counter identity theft or to prevent uncovered claims in e-commerce using e.g. the techniques described in [BüPf90], combined with much anonymity retained. Poorly employed pseudonymity would mean giving away anonymity without preventing uncovered claims.

[45] Providing sender pseudonymity and recipient pseudonymity is the basic interface communication networks have to provide to enhance privacy for two-way communications.




In our usual setting, we assume that each pseudonym refers to exactly one specific holder, invariant over time.

Specific kinds of pseudonyms may extend this setting: A *group pseudonym* refers to a set of holders, i.e. it may refer to multiple holders; a *transferable pseudonym* can be transferred from one holder to another subject becoming its holder.

Such a *group pseudonym* may induce an anonymity set: Using the information provided by the pseudonym only, an attacker cannot decide whether an action was performed by a specific subject within the set. [46]

*Transferable pseudonyms* can, if the attacker cannot completely monitor all transfers of holdership, serve the same purpose, without decreasing accountability as seen by an authority monitoring all transfers of holdership.

An interesting combination might be transferable group pseudonyms – but this is left for further study.

## 10 Pseudonymity with respect to accountability and authorization

### 10.1 Digital pseudonyms to authenticate messages

A *digital pseudonym* is a bit string which, to be meaningful in a certain context, is

- unique as identifier (at least with very high probability) and
- suitable to be used to authenticate the holder's IOIs relatively to his/her digital pseudonym, e.g., to authenticate his/her messages sent.

Using digital pseudonyms, accountability can be realized with pseudonyms – or more precisely: with respect to pseudonyms.

[46] Please note that the mere fact that a pseudonym has several holders does not yield a group pseudonym: For instance, creating the same pseudonym may happen by chance and even without the holders being aware of this fact, particularly if they choose the pseudonyms and prefer pseudonyms which are easy to remember. But the context of each use of the pseudonym (e.g. used by which subject – usually denoted by another pseudonym – in which kind of transaction) then usually will denote a single holder of this pseudonym.

### 10.2 Accountability for digital pseudonyms

To authenticate IOIs relative to pseudonyms usually is not enough to achieve accountability for IOIs.

Therefore, in many situations, it might make sense to either
- attach funds to digital pseudonyms to cover claims or to
- let identity brokers authenticate digital pseudonyms (i.e. check the civil identity of the holder[47] of the pseudonym and then issue a digitally signed statement that this particular identity broker has proof of the identity of the holder of this digital pseudonym and is willing to divulge that proof under well-defined circumstances) or
- both.

If sufficient funds attached to a digital pseudonym are reserved and/or the digitally signed statement of a trusted identity broker is checked before entering into a transaction with the holder of that pseudonym, accountability can be realized in spite of anonymity.

### 10.3 Transferring authenticated attributes and authorizations between pseudonyms

To transfer *attributes including their authentication by third parties* (called "credentials" by David Chaum [Chau85]) – all kinds of *authorizations* are special cases – between digital pseudonyms of one and the same holder, it is always possible to prove that these pseudonyms have the same holder.

But as David Chaum pointed out, it is much more anonymity-preserving to maintain the unlinkability of the digital pseudonyms involved as much as possible by transferring the credential from one pseudonym to the other without proving the sameness of the holder. How this can be done is described in [Chau90, CaLy04].

We will come back to the just described property "convertibility" of digital pseudonyms in Section 12.

## 11 Pseudonymity with respect to linkability[48]

Whereas anonymity and accountability are the extremes with respect to linkability to subjects, pseudonymity is the entire field between and including these extremes. Thus, pseudonymity comprises all degrees of linkability to a subject. Ongoing use of the same pseudonym allows the holder to establish or consolidate a reputation[49]. Some kinds of pseudonyms enable dealing with claims in case of abuse of unlinkability to holders: Firstly, third parties (identity brokers, cf. Section 10.2) may have the possibility to reveal the civil identity of the holder in order to provide

[47] If the holder of the pseudonym is a natural person or a legal person, civil identity has the usual meaning, i.e. the identity attributed to an individual by a State (e.g. represented by the social security number or the combination of name, date of birth, and location of birth etc.). If the holder is, e.g., a computer, it remains to be defined what "civil identity" should mean. It could mean, for example, exact type and serial number of the computer (or essential components of it) or even include the natural person or legal person responsible for its operation.

[48] Linkability is the negation of unlinkability, i.e., items are either more or are either less related than they are related concerning the a-priori knowledge.

[49] Establishing and/or consolidating a reputation under a pseudonym is, of course, insecure if the pseudonym does not enable to authenticate messages, i.e., if the pseudonym is not a digital pseudonym, cf. Section 10.1. Then, at any moment, another subject might use this pseudonym possibly invalidating the reputation, both for the holder of the pseudonym and all others having to do with this pseudonym.

means for investigation or prosecution. To improve the robustness of anonymity, chains of identity brokers may be used [Chau81]. Secondly, third parties may act as liability brokers of the holder to clear a debt or settle a claim. [BüPf90] presents the particular case of value brokers.

There are many properties of pseudonyms which may be of importance in specific application contexts. In order to describe the properties of pseudonyms with respect to anonymity, we limit our view to two aspects and give some typical examples:

### 11.1 Knowledge of the linking between the pseudonym and its holder

The knowledge of the linking may not be a constant but change over time for some or even all people. Normally, for non-transferable pseudonyms the knowledge of the linking cannot decrease.[50] Typical kinds of such pseudonyms are:

a) *public pseudonym*:
   The linking between a public pseudonym and its holder may be publicly known even from the very beginning. E.g., the linking could be listed in public directories such as the entry of a phone number in combination with its owner.
b) *initially non-public pseudonym*:
   The linking between an initially non-public pseudonym and its holder may be known by certain parties, but is not public at least initially. E.g., a bank account where the bank can look up the linking may serve as a non-public pseudonym. For some specific non-public pseudonyms, certification authorities acting as identity brokers could reveal the civil identity of the holder in case of abuse.
c) *initially unlinked pseudonym*:
   The linking between an initially unlinked pseudonym and its holder is – at least initially – not known to anybody with the possible exception of the holder himself/herself. Examples for unlinked pseudonyms are (non-public) biometrics like DNA information unless stored in databases including the linking to the holders.

Public pseudonyms and initially unlinked pseudonyms can be seen as extremes of the described pseudonym aspect whereas initially non-public pseudonyms characterize the continuum in between.

Anonymity is the stronger, the less is known about the linking to a subject. The strength of anonymity decreases with increasing knowledge of the pseudonym linking. In particular, under the assumption that no gained knowledge on the linking of a pseudonym will be forgotten and that the pseudonym cannot be transferred to other subjects, a public pseudonym never can become an unlinked pseudonym. In each specific case, the strength of anonymity depends on the knowledge of certain parties about the linking relative to the chosen attacker model.

If the pseudonym is transferable, the linking to its holder can change. Considering an unobserved transfer of a pseudonym to another subject, a formerly public pseudonym can become non-public again.

[50] With the exception of misinformation or disinformation which may blur the attacker's knowledge (see above).

### 11.2 Linkability due to the use of a pseudonym in different contexts

With respect to the degree of linkability, various kinds of pseudonyms may be distinguished according to the kind of context for their usage:

a) *person pseudonym*:
   A person pseudonym is a substitute for the holder's name which is regarded as representation for the holder's civil identity. It may be used in all contexts, e.g., a number of an identity card, the social security number, DNA, a nickname, the pseudonym of an actor, or a mobile phone number.
b) *role pseudonym*:
   The use of role pseudonyms is limited to specific roles[51], e.g., a customer pseudonym or an Internet account used for many instantiations of the same role "Internet user". The same role pseudonym may be used with different communication partners. Roles might be assigned by other parties, e.g., a company, but they might be chosen by the subject himself/herself as well.
c) *relationship pseudonym*:
   For each communication partner, a different relationship pseudonym is used. The same relationship pseudonym may be used in different roles for communicating with the same partner. Examples are distinct nicknames for each communication partner.[52]
d) *role-relationship pseudonym*:
   For each role and for each communication partner, a different role-relationship pseudonym is used. This means that the communication partner does not necessarily know, whether two pseudonyms used in different roles belong to the same holder. On the other hand, two different communication partners who interact with a user in the same role, do not know from the pseudonym alone whether it is the same user.[53]
e) *transaction pseudonym*[54]:
   For each transaction, a transaction pseudonym unlinkable to any other transaction pseudonyms and at least initially unlinkable to any other IOI is used, e.g., randomly generated transaction numbers for online-banking. Therefore, transaction pseudonyms can be used to realize as strong anonymity as possible.[55]

The strength of the anonymity of these pseudonyms can be represented as the lattice that is illustrated in the following diagram. The arrows point in direction of increasing anonymity, i.e., A → B stands for "B enables stronger anonymity than A".[56]

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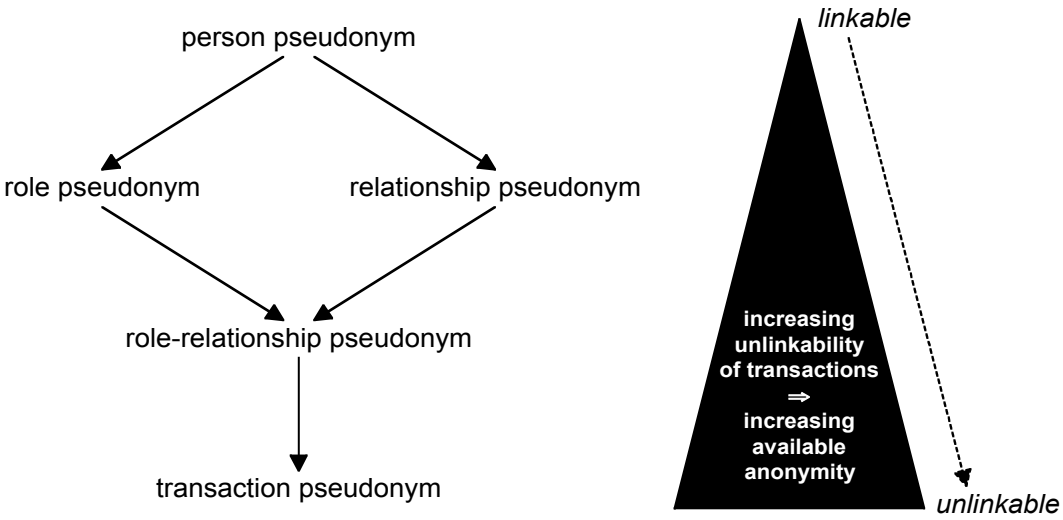
[51] Cf. Section 13.3 for a more precise characterization of "role".
[52] In case of group communication, the relationship pseudonyms may be used between more than two partners.
[53] As with relationship pseudonyms, in case of group communication, the role-relationship pseudonyms may be used between more than two partners.
[54] Apart from "transaction pseudonym" some employ the term "one-time-use pseudonym", taking the naming from "one-time pad".
[55] In fact, the strongest anonymity is given when there is no identifying information at all, i.e., information that would allow linking of anonymous entities, thus transforming the anonymous transaction into a pseudonymous one. If the transaction pseudonym is used exactly once, we have the same strength of anonymity as if no pseudonym is used at all. Another possibility to achieve strong anonymity is to prove the holdership of the pseudonym or specific properties (e.g., with zero-knowledge proofs) without revealing the information about the pseudonym or properties itself. Then, no identifiable or linkable information is disclosed.
[56] "→" is not the same as "⇒" of Section 7, which stands for the implication concerning anonymity and unobservability.




In general, anonymity of both role pseudonyms and relationship pseudonyms is stronger than anonymity of person pseudonyms. The strength of anonymity increases with the application of role-relationship pseudonyms, the use of which is restricted to both the same role and the same relationship.[57] Ultimate strength of anonymity is obtained with transaction pseudonyms, provided that no other linkability information, e.g., from the context, is available.

Anonymity is the stronger, ...
- ... the less personal data of the pseudonym holder can be linked to the pseudonym;
- ... the less often and the less context-spanning pseudonyms are used and therefore the less data about the holder can be linked;
- ... the more often independently chosen, i.e., from an observer's perspective unlinkable, pseudonyms are used for new actions.

The amount of information of linked data can be reduced by different subjects using the same pseudonym (e.g. one after the other when pseudonyms are transferred or simultaneously with specifically created group pseudonyms[58]) or by misinformation or disinformation, cf. footnote in Section 4.

### 12 Known mechanisms and other properties of pseudonyms

A digital pseudonym could be realized as a public key to test digital signatures where the holder of the pseudonym can prove holdership by forming a digital signature which is created using the corresponding private key [Chau81]. The most prominent example for digital pseudonyms are public keys generated by the user himself/herself, e.g., using PGP[59].

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[57] If a role-relationship pseudonym is used for roles comprising many kinds of activities, the danger arises that after a while, it becomes a person pseudonym in the sense of: "A person pseudonym is a substitute for the holder's name which is regarded as representation for the holder's civil identity." This is even more true both for role pseudonyms and relationship pseudonyms.

[58] The group of pseudonym holders acts as an inner anonymity set within a, depending on context information, potentially even larger outer anonymity set.

[59] In using PGP, each user may create an unlimited number of key pairs by himself/herself (at this moment, such a key pair is an initially unlinked pseudonym), bind each of them to an e-mail address, self-certify each public key by using his/her digital signature or asking another introducer to do so, and circulate it.

A *public key certificate* bears a digital signature of a so-called *certification authority* and provides some assurance to the binding of a public key to another pseudonym, usually held by the same subject. In case that pseudonym is the civil identity (the real name) of a subject, such a certificate is called an *identity certificate*. An *attribute certificate* is a digital certificate which contains further information (*attributes*) and clearly refers to a specific public key certificate. Independent of certificates, attributes may be used as identifiers of sets of subjects as well. Normally, attributes refer to sets of subjects (i.e., the anonymity set), not to one specific subject.
There are several other properties of pseudonyms related to their use which shall only be briefly mentioned but not discussed in detail in this text. They comprise different degrees of, e.g.,

- limitation to a fixed number of pseudonyms per subject[60] [Chau81, Chau85, Chau90],
- guaranteed uniqueness[61] [Chau81, StSy00],
- transferability to other subjects,
- authenticity of the linking between a pseudonym and its holder (possibilities of verification/falsification or indication/repudiation),
- provability that two or more pseudonyms have the same holder[62],
- convertibility, i.e., transferability of attributes of one pseudonym to another[63] [Chau85, Chau90],
- possibility and frequency of pseudonym changeover,
- re-usability and, possibly, a limitation in number of uses,
- validity (e.g., guaranteed durability and/or expiry date, restriction to a specific application),
- possibility of revocation or blocking, or
- participation of users or other parties in forming the pseudonyms.

In addition, there may be some properties for specific applications (e.g., addressable pseudonyms serve as a communication address) or due to the participation of third parties (e.g., in order to circulate the pseudonyms, to reveal civil identities in case of abuse, or to cover claims).

Some of the properties can easily be realized by extending a digital pseudonym by attributes of some kind, e.g., a communication address, and specifying the appropriate semantics. The binding of attributes to a pseudonym can be documented in an attribute certificate produced either by the holder himself/herself or by a certification authority. The non-transferability of the attribute certificate can be somewhat enforced e.g. by biometrical means, by combining it with individual hardware (e.g., chipcards), or by confronting the holder with legal consequences.

## 13 Identity management

### 13.1 Setting

To adequately address privacy-enhancing identity management, we have to extend our setting:

- It is not realistic to assume that an attacker might not get information on the sender or recipient of messages from the message content and/or the sending or receiving context (time, location information, etc.) of the message. We have to consider that the attacker is

[60] For pseudonyms issued by an agency that guarantees the limitation of at most one pseudonym per individual, the term “is-a-person pseudonym” is used.
[61] E.g., “globally unique pseudonyms”.
[62] For digital pseudonyms having only one holder each and assuming that no holders cooperate to provide wrong “proofs”, this can be proved trivially by signing e.g. the statement “<Pseudonym1> and <Pseudonym2> have the same holder.” digitally with respect to both these pseudonyms. Putting it the other way round: Proving that pseudonyms have the same holder is all but trivial.
[63] This is a property of convertible credentials.

able to use these properties for linking messages and, correspondingly, the pseudonyms used with them.

- In addition, it is not just human beings, legal persons, or simply computers sending messages and using pseudonyms at their discretion as they like at the moment, but they use application programs, which strongly influence the sending and receiving of messages and may even strongly determine the usage of pseudonyms.

### 13.2 Identity and identifiability

Identity can be explained as an exclusive perception of life, integration into a social group, and continuity, which is bound to a body and shaped by society. This concept of identity[64] distinguishes between "I" and "Me" [Mead34]: "I" is the instance that is accessible only by the individual self, perceived as an instance of liberty and initiative. "Me" is supposed to stand for the social attributes, defining a human identity that is accessible by communications and that is an inner instance of control and consistency.[65]

Corresponding to the anonymity set introduced in the beginning of this text, we can work with an "identifiability set"[66] [Hild03] to define "identifiability" and "identity"[67]:

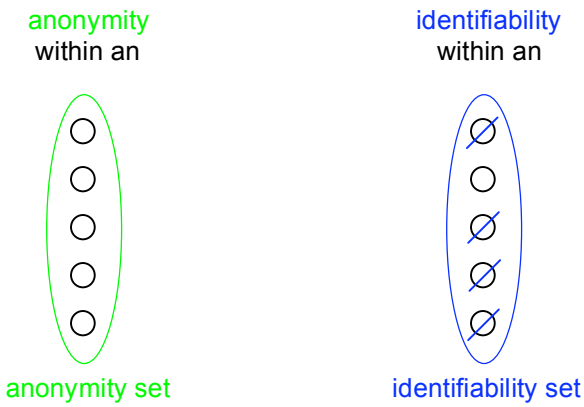
***Identifiability* is the state of being identifiable within a set of subjects, the *identifiability set*.**

[64] Here (and in Section 13 throughout), we have human beings in mind, which is the main motivation for privacy. From a structural point of view, *identity* can be attached to any *subject*, be it a human being, a legal person, or even a computer. This makes the terminology more general, but may lose some motivation at first sight. Therefore, we start in our explanation with identity of human beings, but implicitly generalize to subjects thereafter. This means: In a second reading of this paper, you may replace "individual" by "subject" (introduced as "possibly acting entity" at the beginning of Section 3) throughout as it was used in the definitions of the Sections 2 through 12. It may be discussed whether the definitions can be further generalized and apply for any "entity", regardless of subject or not.

[65] For more information see [ICPP03].

[66] The *identifiability set* is a set of possible subjects.

[67] This definition is compatible with the definitions given in: Giles Hogben, Marc Wilikens, Ioannis Vakalis: On the Ontology of Digital Identification, in: Robert Meersman, Zahir Tari (Eds.): On the Move to Meaningful Internet Systems 2003: OTM 2003 Workshops, LNCS 2889, Springer, Berlin 2003, 579-593; and it is very close to that given by David-Olivier Jaquet-Chiffelle in http://www.calt.insead.edu/fidis/workshop/workshop-wp2-december2003/presentation/VIP/vip_id_def2_files/frame.htm: "An identity is any subset of attributes of a person which uniquely characterizes this person within a community."




All other things being equal, identifiability is the stronger, the larger the respective identifiability set is. Conversely, the remaining anonymity is the stronger, the smaller the respective identifiability set is.

**An *identity* is any subset of attributes of an individual which identifies this individual within any set of individuals.[68] So usually there is no such thing as "the identity", but several of them.**

Of course, attribute values or even attributes themselves may change over time. Therefore, if the attacker has no access to the change history of each particular attribute, the fact whether a particular subset of attributes of an individual is an identity or not may change over time as well. If the attacker has access to the change history of each particular attribute, any subset forming an identity will form an identity from his perspective irrespective how attribute values change.[69]

### 13.3 Identity-related terms

*Role*
In sociology, a "role" or "social role" is a set of connected actions, as conceptualized by actors in a social situation (i.e., situation-dependent identity attributes and properties). It is mostly defined as an expected behavior (i.e., sequences of actions) in a given individual social context.

*Partial identity*
Each identity of a person comprises many partial identities of which each represents the person in a specific context or role. A partial identity is a subset of attributes of a complete identity, where a *complete identity* is the union[70] of all attributes of all identities of this person[71]. On a technical

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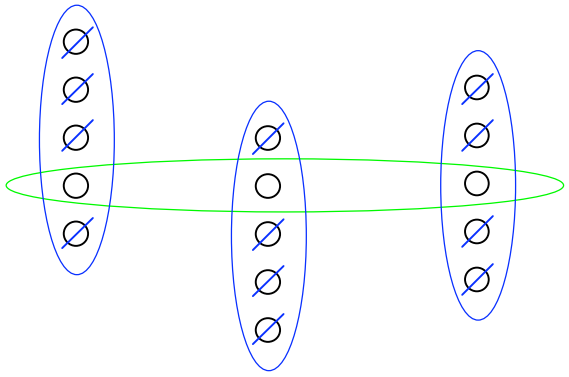
[68] An equivalent, but slightly longer definition of identity would be: An *identity* is any subset of attributes of an individual which distinguishes this individual from all other individuals within any set of individuals.

[69] Any reasonable attacker will not just try to figure out attribute values per se, but the point in time (or even the time frame) they are valid (in), since this change history helps a lot in linking and thus inferring further attribute values. Therefore, it may clarify one's mind to define each "attribute" in a way that its value cannot get invalid. So instead of the attribute "location" of a particular individual, take the set of attributes "location at time x". Depending on the inferences you are interested in, refining that set as a list ordered concerning "location" or "time" may be helpful.

[70] If attributes are defined such that they don't get invalid (cf. last footnote in Section 13.2), "union" can have the usual meaning within set theory.

[71] We have to admit that usually nobody, including the person concerned, will know "all" attributes nor "all" identities. Nevertheless we hope that the notion "complete identity" will ease the understanding of "identity" and "partial identity".

level, these attributes are data. Of course, attribute values or even attributes themselves of a partial identity may change over time.
A *pseudonym* might be an identifier for a partial identity.[72]
Whereas we assume that an "identity" uniquely characterizes an individual (without limitation to particular identifiability sets), a partial identity may not do, thereby enabling different quantities of anonymity. But we may find for each partial identity appropriately small identifiability sets[73], where the partial identity uniquely characterizes an individual.[74]
As with identities, depending on whether the attacker has access to the change history of each particular attribute or not, the identifiability set of a partial identity may change over time if the values of its attributes change.



anonymity set of a partial identity given that the set of all possible subjects (the a-priori anonymity set, cf. footnote, case 1.) can be partitioned into the three disjoint identifiability sets of the partial identity shown

*Digital identity*
Digital identity denotes attribution of properties to a person, which are immediately operationally accessible by technical means. More to the point, the identifier of a digital partial identity[75] can be a simple e-mail address in a news group or a mailing list. Its owner will attain a certain reputation. More generally we might consider the whole identity as a combination from "I" and "Me" where the "Me" can be divided into an implicit and an explicit part: Digital identity is the digital part from the explicated "Me". Digital identity should denote all those personally related data that can be stored and automatically interlinked by a computer-based application.

*Virtual identity*
Virtual identity is sometimes used in the same meaning as digital identity or digital partial identity, but because of the connotation with "unreal, non-existent, seeming" the term is mainly applied to

[72] If it is possible to transfer attributes of one pseudonym to another (as convertibility of credentials provides for, cf. Section 12), this means transferring a partial identity to this other pseudonym.
[73] For identifiability sets of cardinality 1, this is trivial, but it may hold for "interesting" identifiability sets of larger cardinality as well.
[74] The relation between *anonymity set* and *identifiability set* can be seen in two ways:
1. Within an a-priori anonymity set, we can consider a-posteriori identifiability sets as subsets of the anonymity set. Then the largest identifiability sets allowing identification characterize the a-posteriori anonymity, which is zero iff the largest identifiability set allowing identification equals the a-priori anonymity set.
2. Within an a-priori identifiability set, its subsets which are the a-posteriori anonymity sets characterize the a-posteriori anonymity. It is zero iff all a-posteriori anonymity sets have cardinality 1.

[75] A *digital partial identity* is the same as a *partial digital identity*. In the sequel, we skip "partial" if the meaning is clear from the context.

characters in a MUD (Multi User Dungeon), MMORPG (Massively Multiplayer Online Role Playing Games) or to avatars.

### 13.4 Identity management-related terms

*Identity management*
*Identity management* means managing various partial identities (usually denoted by pseudonyms) of the individual, i.e. administration and design of identity attributes as well as choice of the partial identity and pseudonym to be (re-)used in a specific context or role. Establishment of *reputation* is possible when the individual re-uses partial identities. A prerequisite to choose the appropriate partial identity is to recognize the situation the person is acting in.

*Privacy-enhancing identity management*
Given the restrictions of an application, identity management is called *perfectly privacy-enhancing* if by choosing the pseudonyms and their authorizations (cf. Section 10.3) carefully, it does not provide more linkability between partial identities to an attacker than giving the attacker the data with all pseudonyms omitted.
The identity management is called *privacy enhancing* if it does not provide essentially[76] more linkability between the partial identities.[77]

*Privacy-enhancing identity management enabling application design*
An application is designed in a privacy-enhancing identity management enabling way if neither the pattern of sending/receiving messages nor the attributes given to entities (i.e., human beings, organizations, computers) imply more linkability than is strictly necessary to achieve the purposes of the application.

*Identity management system (IMS)*[78]
Technology-based identity management in its broadest sense refers to administration and design of identity attributes.
We can distinguish between identity management system[79] and identity management application: The term “identity management system” is seen as an infrastructure, in which “identity management applications” as components are co-ordinated. Identity management applications are tools for individuals to manage their socially relevant communications, which can be installed, configured and operated at the user’s and/or a server’s side.
A technically supported identity management has to empower the user to recognize different kinds of communication or social situations and to assess them with regards to their relevance, functionality and their security and privacy risk in order to make and take roles adequately.

---

[76] “Essentially” is just a term used because we have not precisely defined a measure. If we define a measure, “essentially” would mean “too much”.
[77] Note that due to our setting, this definition focuses on the main property of Privacy-Enhancing Technologies (PETs), namely data minimization: This property means to limit as much as possible the release of personal data and for that released, ensure as much unlinkability as possible. We are aware of the limitation of this definition: In the real world it is not always desired to achieve utmost unlinkability. We believe that the user as the data subject should be empowered to decide on the release of data and on the degree of linkage of his or her personal data within the boundaries of legal regulations, i.e., in an advanced setting the privacy-enhancing application design should also take into account the support of “user-controlled release” as well as “user-controlled linkage”.
[78] Some publications use the abbreviations IdMS or IDMS instead.
[79] There are several different examples which are called Identity Management Systems, e.g. managing person-related data of employees/ customers within organizations or Single Sign-On systems. We are interested in the more general case of user-controlled IMS, i.e., involving users in IMS directly.

In general the identity management application should help the user in managing one's partial identities, meaning that different pseudonyms with associated data sets can be used according to different roles the user is acting in and according to different communication partners.

*Privacy-enhancing identity management system (PE-IMS)*
A Privacy-Enhancing IMS makes the flow of personal data explicit and gives its user a larger degree of control [CPHH02]. The guiding principle is "notice and choice", based on a high level of data minimization: This means user-controlled linkability of personal data.[80]
According to respective situation and context, such a system supports the user in making an informed choice of pseudonyms, representing his or her partial identities. A PE-IMS supports the user in managing his or her partial identities, i.e., in particular the processes of role taking and role making. It acts as a central gateway for all communication between different applications, like browsing the web, buying in Internet shops, or carrying out administrative tasks with governmental authorities [HBCC04].

## 14 Concluding remarks

This text is a consolidated proposal for terminology in the field "anonymity, (un)linkability, (un)observability, pseudonymity, and identity management". The authors hope to get further feedback to improve this text and to come to a more precise and comprehensive terminology. Everybody is invited to participate in the process of defining an essential set of terms.

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[80] And by default unlinkability of different user actions so that communication partners involved in different actions by the same user cannot combine the personal data disseminated during these actions.

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**Relationships between some terms used**

For terms used in this document, the following “is”-relation (subclass hierarchy) holds:

items of interest (IOI) <are>
- entity
  - subject
    - human being (= natural person)
    - legal person
    - computer
      - sender of a message
      - recipient of a message
  - object
- message
- actions
  - sending of message
  - receiving of message
- identifier
  - name
  - pseudonym
    - digital pseudonym

In addition, we would like to have a notation for a “may have”-relation. Thereby, we give the most general relation. In the example below, “subject” may have “digital pseudonym” implies that “objects” may have no “digital pseudonym”.

Subject <may have>
- digital pseudonym

{If, e.g. in the area of ontologies, there is some other standard notation for this, please let us know.}

**Index**

**Translation of essential terms**

**To Czech**

Vashek Matyas, Masaryk Univ. Brno, Czech republic
matyas@fi.muni.cz

Zdenek Riha, Masaryk Univ. Brno, Czech republic
zriha@fi.muni.cz

Alena Honigova
alena_honigova@itse.cz

| | |
|---|---|
| absolute anonymity | absolutní anonymita |
| absolute unlinkability | absolutní nespojitelnost |
| abuse | zneužít, zneužití |
| accountability | prokazatelná odpovědnost |
| accountability in spite of anonymity | prokazatelná odpovědnost i přes anonymitu |
| accountability with respect to a pseudonym | prokazatelná odpovědnost vzhledem k pseudonymu |
| acting entity | jednající entita |
| action | jednání, čin, akce |
| addressable pseudonym | adresovatelný pseudonym |
| anonymity | anonymita |
| anonymity set | anonymitní množina |
| anonymous | anonymní |
| a-posteriori knowledge | a posteriori (znalost po události) |
| application design | návrh aplikace |
| a-priori knowledge | a priori (znalost před událostí) |
| attacker | útočník |
| attacker model | model útočníka |
| attribute | atribut |
| attribute authentication by third parties | atributová autentizace za pomoci třetí strany |
| attribute certificate | atributový certifikát |
| attribute values | hodnoty atributů |
| authentication | autentizace |
| avatar | zosobnění |
| background knowledge | znalost prostředí / pozadí |
| biometrics | biometrika |
| blocking | blokující, blokování |
| broadcast | vysílání, broadcast |
| certification authority | certifikační autorita |
| chains of identity brokers | řetězce zprostředkovatelů identity |

| | |
|---|---|
| change history | historie změn |
| civil identity | občanská totožnost/identita |
| communication network | komunikační síť |
| communication relationships | komunikační vztahy |
| complete identity | úplná totožnost/identita |
| computer | počítač |
| context | kontext |
| convertibility | převoditelnost |
| convertibility of digital pseudonyms | převoditelnost digitálních pseudonymů |
| cover claims | pokrýt nároky |
| credential | autorizační atributy |
| customer pseudonym | pseudonym zákazníka |
| data minimization | minimalizace dat |
| data protection regulations | předpisy pro ochranu (osobních) dat |
| data subject | dotčený (subjekt dat) |
| DC-net | DC-síť |
| digital identity | digitální identita |
| digital partial identity | digitální částečná identita |
| digital pseudonym | digitální pseudonym |
| digital signature | digitální podpis |
| disinformation | dezinformace (záměrná) |
| distinguish | odlišit |
| dummy traffic | nevýznamný / umělý provoz |
| encryption | (za)šifrování |
| end-to-end encryption | šifrování mezi koncovými uzly (end-to-end) |
| entity | entita |
| entropy | entropie |
| forget | zapomenout |
| globally unique pseudonym | globálně jedinečný pseudonym |
| group communication | skupinová komunikace |
| group pseudonym | skupinový pseudonym |
| holder | držitel |
| holder of the pseudonym | držitel pseudonymu |
| human being | lidská bytost |
| I | já |
| identifiability | identifikovatelnost |
| identifiability set | identifikovatelnostní množina |
| identifiable | identifikovatelný |
| identifier | identifikátor |
| identifier of a subject | identifikátor subjektu |
| identity | identita, totožnost |
| identity broker | zprostředkovatel identity |
| identity card | občanský průkaz, identifikační průkaz |
| identity certificate | certifikát identity |
| identity management | správa identit |
| identity management application | aplikace pro správu identity |
| identity management system | systém správy identit |
| identity theft | krádež identity |
| imply | implikovat, znamenat |
| IMS | IMS |
| indistinguishability | nerozlišitelnost |
| indistinguishable | nerozlišitelný |
| individual | individuální |
| initially non-public pseudonym | zpočátku neveřejný pseudonym |
| initially unlinked pseudonym | zpočátku nespojený pseudonym |
| insider | vnitřní činitel |

| | |
|---|---|
| introducer | předkladatel, uvaděč |
| is-a-person pseudonym | pseudonym je-osobou |
| items of interest | předměty zájmu |
| key | klíč |
| knowledge | znalost |
| largest possible anonymity set | největší možná anonymitní množina |
| lattice | mřížka |
| legal person | právnická osoba |
| liability broker | zprostředkovatel odpovědnosti |
| linkability | spojitelnost |
| linkability between the pseudonym and its holder | spojitelnost mezi pseudonymem a jeho držitelem |
| linkability broker | zprostředkovatel spojitelnosti |
| Me | o mně (“Me”) |
| mechanisms | mechanizmy |
| mechanisms for anonymity | mechanizmy pro anonymitu |
| mechanisms for unobservability | mechanizmy pro nepozorovatelnost |
| message | zpráva |
| message content | obsah zprávy |
| misinformation | nesprávná / mylná informace |
| MIX-net | mixovací síť |
| mobile phone number | číslo mobilního telefonu |
| name | jméno |
| natural person | fyzická osoba |
| new knowledge | nová znalost |
| non-public pseudonym | neveřejný pseudonym |
| notice and choice | oznámení a volba |
| nym | -nym |
| nymity | -nymita |
| observation | pozorování |
| one-time pad | jednorázové heslo |
| one-time-use pseudonym | jednorázový pseudonym |
| organization | organizace |
| outsider | vnější činitel |
| owner | vlastník |
| partial digital identity | částečná digitální identita |
| partial identity | částečná identita |
| perfect secrecy | dokonalé utajení |
| person pseudonym | pseudonym osoby |
| perspective | perspektiva, úhel pohledu |
| precise | přesný |
| privacy | soukromí |
| privacy-enhancing application design | návrh aplikace zvyšující ochranu soukromí |
| privacy-enhancing identity management system | systém správy identity zvyšující ochranu soukromí |
| Privacy-Enhancing Technologies | technologie zvyšující ochranu soukromí |
| private information retrieval | vyhledávání/získávání soukromých informací |
| private key | soukromý / privátní klíč |
| probabilities | pravděpodobnosti |
| property | vlastnost |
| pseudonym | pseudonym |
| pseudonymity | pseudonymita |
| pseudonymization | pseudonymizace |
| pseudonymous | pseudonymní (pod pseudonymem) |
| public key | veřejný klíč |
| public key certificate | certifikát veřejného klíče |

| | |
|---|---|
| public pseudonym | veřejný pseudonym |
| quality of anonymity | úroveň / kvalita anonymity |
| quantify pseudonymity | kvantifikovat pseudonymitu |
| quantify unlinkability | kvantifikovat nespojitelnost |
| quantify unobservability | kvantifikovat nepozorovatelnost |
| quantity of anonymity | kvantifikovat anonymitu |
| real name | skutečné jméno |
| recipient | příjemce |
| recipient anonymity | anonymita příjemce |
| recipient anonymity set | anonymitní množina příjemců |
| recipient pseudonymity | pseudonymita příjemce |
| recipient unobservability | nepozorovatelnost příjemce |
| recipient unobservability set | nepozorovatelnostní množina příjemců |
| relationship anonymity | anonymita vztahu |
| relationship anonymity set | <Your input needed> |
| relationship pseudonym | pseudonym vztahu |
| relationship unobservability | nepozorovatelnost vztahu |
| relationship unobservability set | <Your input needed> |
| relative unlinkability | relativní nespojitelnost |
| reputation | pověst, reputace |
| revocation | odvolání |
| robustness of anonymity | robustnost anonymity |
| role | role |
| role pseudonym | pseudonym role |
| role-relationship pseudonym | pseudonym role-vztah |
| semantic dummy traffic | sémantický umělý provoz |
| sender | odesilatel |
| sender anonymity | anonymita odesilatele |
| sender anonymity set | anonymitní množina odesilatelů |
| sender pseudonymity | pseudonymita odesilatele |
| sender unobservability | nepozorovatelnostní množina |
| sender unobservability set | nepozorovatelnostní množina odesilatelů |
| sender-recipient-pairs | dvojice odesilatel-příjemce |
| set | množina |
| set of subjects | množina subjektů |
| setting | nastavení |
| side channel | postranní kanál |
| social role | sociální role |
| social security number | číslo sociálního zabezpečení |
| spread spectrum | rozložené spektrum |
| state | stav |
| steganographic systems | steganografické systémy |
| steganography | steganografie |
| strength of anonymity | síla/odolnost anonymity |
| subject | subjekt |
| surrounding | okolní |
| system | systém |
| transaction pseudonym | transakční pseudonym |
| transfer of holdership | změna držení (vlastnictví) |
| transferability | převoditelnost |
| transferable group pseudonym | převoditelný pseudonym skupiny |
| transferable pseudonym | převoditelný pseudonym |
| undetectability | <Your input needed> |
| uniqueness | jedinečnost |
| universe | universum |
| unlinkability | nespojitelnost |

| | |
|---|---|
| unobservability | nepozorovatelnost |
| unobservability set | nepozorovatelnostní množina |
| user-controlled linkage | uživatelem řízené spojení |
| user-controlled release | uživatelem řízené zveřejnění |
| usual suspects | obvyklí podezřelí |
| value broker | zprostředkovatel hodnoty |
| virtual identity | virtuální identita |
| zero-knowledge proof | důkaz s nulovým rozšířením znalosti |

**To French**

Dr. Yves Deswarte, LAAS-CNRS
Yves.Deswarte@laas.fr

Here is the color code I used:

- I indicate in black those terms that should be easily accepted.
- In blue are neologisms that I propose, i.e. they are not (currently) French words or expressions, but I think that most French people would understand them. So they'd be generally preferable to existing French expressions that would be ambiguous or too long. (But some rigorous French people do not accept easily neologisms).
- In red are the terms or expressions that translate (as well as I can) the English terms or expressions, but are not exactly equivalent. Other French speakers may prefer other expressions or find better translations.
- In some cases (e.g., for pseudonymity or linkability), I indicated my proposal (in blue since it is a neologism) and an "official" expression in red (e.g., from the official French version of the Common Criteria). In other cases I indicated several possibilities in red, when I could not decide which I feel better (I'd chose probably one or the other one according to the context).

I'd recommend other French speaking partners to check at least those blue and red expressions.

| | |
|---|---|
| absolute anonymity | anonymat absolu |
| absolute unlinkability | inassociabilité absolue, impossibilité absolue d'établir un lien |
| abuse | abus |
| accountability | responsabilité |
| accountability in spite of anonymity | responsabilité malgré l'anonymat |
| accountability with respect to a pseudonym | responsabilité par rapport à un pseudonyme |
| acting entity | agent |
| action | action |
| addressable pseudonym | pseudonyme adressable |
| anonymity | anonymat |
| anonymity set | ensemble d'anonymat |
| anonymous | anonyme |
| a-posteriori knowledge | connaissance a posteriori |
| application design | conception d'application |
| a-priori knowledge | connaissance a priori |
| attacker | attaquant |
| attacker model | modèle d'attaquant |
| attribute | attribut |
| attribute authentication by third parties | authentification d'attribut par tierces parties |

| | |
|---|---|
| attribute certificate | certificat d'attribut |
| attribute values | valeurs d'attributs |
| authentication | authentification |
| avatar | avatar |
| background knowledge | connaissance de fond |
| biometrics | biométrie |
| blocking | blocage |
| broadcast | diffusion |
| certification authority | autorité de certification |
| chains of identity brokers | chaînes de courtiers d'identité |
| change history | historique des modifications |
| civil identity | identité civile |
| communication network | réseau de communication |
| communication relationships | relations de communication |
| complete identity | identité complète |
| computer | ordinateur |
| context | contexte |
| convertibility | convertibilité |
| convertibility of digital pseudonyms | convertibilité de pseudonymes numériques |
| cover claims | couvrir des dommages |
| credential | garantie |
| customer pseudonym | pseudonyme du client |
| data minimization | minimisation des données |
| data protection regulations | règlementation sur la protection des données |
| data subject | sujet auquel se rapportent les données |
| DC-net | réseau-DC |
| digital identity | identité numérique |
| digital partial identity | identité numérique partielle |
| digital pseudonym | pseudonyme numérique |
| digital signature | signature numérique |
| disinformation | fausse information |
| distinguish | distinguer |
| dummy traffic | traffic factice |
| encryption | chiffrement |
| end-to-end encryption | chiffrement de bout-en-bout |
| entity | entité |
| entropy | entropie |
| forget | oublier |
| globally unique pseudonym | pseudonyme globalement unique |
| group communication | communication de groupe |
| group pseudonym | pseudonyme de groupe |
| holder | détenteur |
| holder of the pseudonym | détenteur du pseudonyme |
| human being | être humain |
| I | Je |
| identifiability | identifiabilité |
| identifiability set | ensemble d'identifiabilité |
| identifiable | identifiable |
| identifier | identificateur |
| identifier of a subject | identificateur d'un sujet |
| identity | identité |
| identity broker | courtier d'identité |
| identity card | carte d'identité |
| identity certificate | certificat d'identité |
| identity management | gestion des identités |
| identity management application | application de gestion des identités |

| | |
|---|---|
| identity management system | système de gestion des identités |
| identity theft | vol d'identité |
| imply | impliquer |
| IMS | SGI |
| indistinguishability | indistingabilité |
| indistinguishable | indistingable |
| individual | individuel |
| initially non-public pseudonym | pseudonyme initialement non-public |
| initially unlinked pseudonym | pseudonyme initialement non-relié |
| insider | [quelqu'un] de l'intérieur |
| introducer | introducteur |
| is-a-person pseudonym | pseudonyme est-une-personne |
| items of interest | éléments d'intrêt |
| key | clé |
| knowledge | connaissance |
| largest possible anonymity set | le plus grand ensemble d'anonymat possible |
| lattice | treillis |
| legal person | personne morale |
| liability broker | garant |
| linkability | associabilité, possibilité d'établir un lien |
| linkability between the pseudonym and its holder | associabilité entre le pseudonyme et son détenteur, possibilité d'établir un lien entre le pseudonyme et son détenteur |
| linkability broker | autorité de liaison |
| Me | Moi |
| mechanisms | mécanismes |
| mechanisms for anonymity | mécanismes d'anonymat |
| mechanisms for unobservability | mécanismes d'inobservabilité |
| message | message |
| message content | contenu du message |
| misinformation | mauvaise information |
| MIX-net | réseau de MIX |
| mobile phone number | numéro de téléphone portable |
| name | nom |
| natural person | personne réelle |
| new knowledge | connaissance nouvelle |
| non-public pseudonym | pseudonyme non-public |
| notice and choice | notification et choix |
| nym | nyme |
| nymity | nymité |
| observation | observation |
| one-time pad | masque jetable |
| one-time-use pseudonym | pseudonyme jetable (ou pseudonyme à usage unique) |
| organization | organisation |
| outsider | [quelqu'un] de l'extérieur |
| owner | propriétaire |
| partial digital identity | identité numérique partielle |
| partial identity | identité partielle |
| perfect secrecy | secret parfait |
| person pseudonym | pseudonyme de personne |
| perspective | point de vue |
| precise | précis |
| privacy | [protection de la] vie privée, intimité |
| privacy-enhancing application design | conception d'application préservant la vie privée |

| | |
|---|---|
| privacy-enhancing identity management system | système de gestion des identités préservant la vie privée |
| Privacy-Enhancing Technologies | Technologies de Protection de la Vie Privée |
| private information retrieval | récupération d'information |
| private key | clé privée |
| probabilities | probabilités |
| property | propriété |
| pseudonym | pseudonyme |
| pseudonymity | pseudonymat, possibilité d'agir sous un pseudonyme |
| pseudonymization | pseudonymisation |
| pseudonymous | pseudonymique |
| public key | clé publique |
| public key certificate | certificat à clé publique |
| public pseudonym | pseudonyme public |
| quality of anonymity | qualité d'anonymat |
| quantify pseudonymity | quantifier le pseudonymat |
| quantify unlinkability | quantifier l'inassociabilité, quantifier la difficulté à établir un lien |
| quantify unobservability | quantifier l'inobservabilité |
| quantity of anonymity | quantifier l'anonymat |
| real name | nom réel |
| recipient | recepteur |
| recipient anonymity | anonymat de réception |
| recipient anonymity set | ensemble d'anonymat de réception |
| recipient pseudonymity | pseudonymat de réception |
| recipient unobservability | inobservabilité de réception |
| recipient unobservability set | ensemble d'inobservabilité de réception |
| relationship anonymity | anonymat de relation |
| relationship anonymity set | <Your input needed> |
| relationship pseudonym | pseudonymat de relation |
| relationship unobservability | inobservabilité de relation |
| relationship unobservability set | <Your input needed> |
| relative unlinkability | inassociabilité relative |
| reputation | réputation |
| revocation | révocation |
| robustness of anonymity | robustesse d'anonymat |
| role | rôle |
| role pseudonym | pseudonyme de rôle |
| role-relationship pseudonym | pseudonyme de rôle et de relation |
| semantic dummy traffic | trafic sémantique factice |
| sender | émetteur |
| sender anonymity | anonymat d'émission |
| sender anonymity set | ensemble d'anonymat d'émission |
| sender pseudonymity | pseudonymat d'émission |
| sender unobservability | inobservabilité d'émission |
| sender unobservability set | ensemble d'inobservabilité d'émission |
| sender-recipient-pairs | paires d'émetteurs-récepteurs |
| set | ensemble |
| set of subjects | ensemble de sujets |
| setting | configuration |
| side channel | canal de fuite |
| social role | rôle social |
| social security number | numéro de sécurité sociale |
| spread spectrum | étalement de spectre |
| state | état |

| | |
|---|---|
| steganographic systems | systèmes stéganographiques |
| steganography | stéganographie |
| strength of anonymity | force d'anonymat |
| subject | sujet |
| surrounding | environnement |
| system | système |
| transaction pseudonym | pseudonyme de transaction |
| transfer of holdership | transfert de détention |
| transferability | transférabilité |
| transferable group pseudonym | pseudonyme de groupe transférable |
| transferable pseudonym | pseudonyme transférable |
| undetectability | <Your input needed> |
| uniqueness | unicité |
| universe | univers |
| unlinkability | inassociabilité, impossibilité d'établir un lien |
| unobservability | inobservabilité |
| unobservability set | ensemble d'inobservabilité |
| user-controlled linkage | établissement de lien sous le contrôle de l'utilisateur |
| user-controlled release | divulgation sous le contrôle de l'utilisateur |
| usual suspects | suspects habituels |
| value broker | courtier de valeurs |
| virtual identity | identité virtuelle |
| zero-knowledge proof | preuve sans divulgation de connaissance |

**To German**

| | |
|---|---|
| absolute anonymity | absolute Anonymität |
| absolute unlinkability | absolute Unverkettbarkeit |
| abuse | Missbrauch |
| accountability | Zurechenbarkeit |
| accountability in spite of anonymity | Zurechenbarkeit trotz Anonymität |
| accountability with respect to a pseudonym | Zurechenbarkeit zu einem Pseudonym |
| acting entity | handelnde Entität |
| action | Handlung |
| addressable pseudonym | adressierbares Pseudonym |
| anonymity | Anonymität |
| anonymity set | Anonymitätsmenge |
| anonymous | anonym |
| a-posteriori knowledge | A-Posteriori-Wissen |
| application design | Anwendungsentwurf |
| a-priori knowledge | A-Priori-Wissen |
| attacker | Angreifer |
| attacker model | Angreifermodell |
| attribute | Attribut |
| attribute authentication by third parties | Attributauthentisierung durch Dritte |
| attribute certificate | Attributzertifikat |
| attribute values | Attributwerte |
| authentication | Authentisierung |
| avatar | Avatar |
| background knowledge | Hintergrundwissen |
| biometrics | Biometrie |
| blocking | Sperren |
| broadcast | Verteilung |
| certification authority | Zertifizierungsinstanz |

| | |
|---|---|
| chains of identity brokers | Ketten von Identitätstreuhändern |
| change history | Änderungshistorie |
| civil identity | zivile Identität |
| communication network | Kommunikationsnetz |
| communication relationships | Kommunikationsbeziehungen |
| complete identity | vollständige Identität |
| computer | Rechner |
| context | Kontext |
| convertibility | Umrechenbarkeit |
| convertibility of digital pseudonyms | Umrechenbarkeit digitaler Pseudonyme |
| cover claims | Forderungen abdecken |
| credential | Credential |
| customer pseudonym | Kundenpseudonym |
| data minimization | Datenminimierung |
| data protection regulations | Datenschutzregelungen |
| data subject | Betroffener |
| DC-net | DC-Netz |
| digital identity | digitale Identität |
| digital partial identity | digitale partielle Identität |
| digital pseudonym | digitales Pseudonym |
| digital signature | digitale Signatur |
| disinformation | Desinformation |
| distinguish | unterscheiden |
| dummy traffic | bedeutungsloser Verkehr |
| encryption | Verschlüsselung |
| end-to-end encryption | Ende-zu-Ende-Verschlüsselung |
| entity | Entität |
| entropy | Entropie |
| forget | vergessen |
| globally unique pseudonym | global eindeutiges Pseudonym |
| group communication | Gruppenkommunikation |
| group pseudonym | Gruppenpseudonym |
| holder | Inhaber |
| holder of the pseudonym | Inhaber des Pseudonyms |
| human being | Mensch |
| I | “I” |
| identifiability | Identifizierbarkeit |
| identifiability set | Identifizierbarkeitsmenge |
| identifiable | identifizierbar |
| identifier | Identifikator |
| identifier of a subject | Identifikator eines Subjektes |
| identity | Identität |
| identity broker | Identitätstreuhänder |
| identity card | Ausweis |
| identity certificate | Identitätszertifikat |
| identity management | Identitätsmanagement |
| identity management application | Identitätsmanagementanwendung |
| identity management system | Identitätsmanagementsystem |
| identity theft | Identitätsdiebstahl |
| imply | implizieren |
| IMS | IMS |
| indistinguishability | Ununterscheidbarkeit |
| indistinguishable | ununterscheidbar |
| individual | Individuum |
| initially non-public pseudonym | initial nicht-öffentliches Pseudonym |
| initially unlinked pseudonym | initial unverkettetes Pseudonym |

| | |
|---|---|
| insider | Insider |
| introducer | Introducer, Bekanntmacher |
| is-a-person pseudonym | Ist-eine-Person-Pseudonym |
| items of interest | interessierende Dinge |
| key | Schlüssel |
| knowledge | Wissen |
| largest possible anonymity set | größtmögliche Anonymitätsmenge |
| lattice | Verband |
| legal person | juristische Person |
| liability broker | Treuhänder für Verbindlichkeiten |
| linkability | Verkettbarkeit |
| linkability between the pseudonym and its holder | Verkettbarkeit zwischen dem Pseudonym und seinem Inhaber |
| linkability broker | Verkettbarkeitstreuhänder |
| Me | “Me” |
| mechanisms | Mechanismen |
| mechanisms for anonymity | Mechanismen für Anonymität |
| mechanisms for unobservability | Mechanismen für Unbeobachtbarkeit |
| message | Nachricht |
| message content | Nachrichteninhalt |
| misinformation | Missinformation |
| MIX-net | MIX-Netz |
| mobile phone number | Mobiltelefonnummer |
| name | Name |
| natural person | natürliche Person |
| new knowledge | neues Wissen |
| non-public pseudonym | nicht-öffentliches Pseudonym |
| notice and choice | “Notice and Choice” (d.h. Information des Betroffenen und Gelegenheit zur eigenen Entscheidung über die Verarbeitung der Daten) |
| nym | Nym |
| nymity | Nymity |
| observation | Beobachtung |
| one-time pad | One-Time-Pad |
| one-time-use pseudonym | einmal zu benutzendes Pseudonym |
| organization | Organisation |
| outsider | Außenstehender |
| owner | Eigentümer |
| partial digital identity | digitale Teilidentität |
| partial identity | Teilidentität |
| perfect secrecy | perfekte Geheimhaltung |
| person pseudonym | Personenpseudonym |
| perspective | Sicht |
| precise | präzise |
| privacy | Privatheit |
| privacy-enhancing application design | Privatheit fördernder Anwendungsentwurf |
| privacy-enhancing identity management system | Privatheit förderndes Identitätsmanagementsystem |
| Privacy-Enhancing Technologies | Privatheit fördernde Technik |
| private information retrieval | Abfragen und Überlagern |
| private key | privater Schlüssel |
| probabilities | Wahrscheinlichkeiten |
| property | Eigenschaft |
| pseudonym | Pseudonym |
| pseudonymity | Pseudonymität |

| | |
|---|---|
| pseudonymization | Pseudonymisierung |
| pseudonymous | pseudonym |
| public key | öffentlicher Schlüssel |
| public key certificate | Zertifikat für den öffentlichen Schlüssel |
| public pseudonym | öffentliches Pseudonym |
| quality of anonymity | Anonymitätsqualität |
| quantify pseudonymity | Pseudonymität quantifizieren |
| quantify unlinkability | Unverkettbarkeit quantifizieren |
| quantify unobservability | Unbeobachtbarkeit quantifizieren |
| quantity of anonymity | Anonymitätsquantität |
| real name | wirklicher Name |
| recipient | Empfänger |
| recipient anonymity | Empfängeranonymität |
| recipient anonymity set | Empfängeranonymitätsmenge |
| recipient pseudonymity | Empfängerpseudonymität |
| recipient unobservability | Empfängerunbeobachtbarkeit |
| recipient unobservability set | Empfängerunbeobachtbarkeitsmenge |
| relationship anonymity | Beziehungsanonymität |
| relationship anonymity set | Beziehungsanonymitätsmenge |
| relationship pseudonym | Beziehungspseudonym |
| relationship unobservability | Beziehungsunbeobachtbarkeit |
| relationship unobservability set | Beziehungsunbeobachtbarkeitsmenge |
| relative unlinkability | keine Verkettbarkeitsänderung |
| reputation | Reputation |
| revocation | Widerruf |
| robustness of anonymity | Anonymitätsrobustheit |
| role | Rolle |
| role pseudonym | Rollenpseudonym |
| role-relationship pseudonym | Rollenbeziehungspseudonym |
| semantic dummy traffic | (den Angreifer) irreführender Verkehr |
| sender | Sender |
| sender anonymity | Senderanonymität |
| sender anonymity set | Senderanonymitätsmenge |
| sender pseudonymity | Senderpseudonymität |
| sender unobservability | Senderunbeobachtbarkeit |
| sender unobservability set | Senderunbeobachtbarkeitsmenge |
| sender-recipient-pairs | Sender-Empfänger-Paare |
| set | Menge |
| set of subjects | Subjektmenge |
| setting | Szenario |
| side channel | Seitenkanal |
| social role | soziale Rolle |
| social security number | Sozialversicherungsnummer |
| spread spectrum | Spreizband |
| state | Zustand |
| steganographic systems | Stegosysteme |
| steganography | Steganographie |
| strength of anonymity | Anonymitätsstärke |
| subject | Subjekt |
| surrounding | Umgebung |
| system | System |
| transaction pseudonym | Transaktionspseudonym |
| transfer of holdership | Transfer der Inhaberschaft |
| transferability | Transferierbarkeit |
| transferable group pseudonym | transferierbares Gruppenpseudonym |
| transferable pseudonym | transferierbares Pseudonym |

| | |
|---|---|
| undetectability | Unerkennbarkeit |
| uniqueness | Eindeutigkeit |
| universe | Universum |
| unlinkability | Unverkettbarkeit |
| unobservability | Unbeobachtbarkeit |
| unobservability set | Unbeobachtbarkeitsmenge |
| user-controlled linkage | benutzerkontrollierte Verkettung |
| user-controlled release | benutzerkontrollierte Freigabe |
| usual suspects | die üblichen Verdächtigen |
| value broker | Wertetreuhänder |
| virtual identity | virtuelle Identität |
| zero-knowledge proof | Zero-Knowledge-Beweis |

**To Greek**

Prof. Stefanos Gritzalis, University of the Aegean, Greece
sgritz@aegean.gr http://www.icsd.aegean.gr/sgritz

Christos Kalloniatis, Researcher, University of the Aegean, Greece
ch.kalloniatis@ct.aegean.gr

| | |
|---|---|
| absolute anonymity | απόλυτη ανωνυμία |
| absolute unlinkability | απόλυτη μη-συνδεσιμότητα |
| abuse | κατάχρηση |
| accountability | ευθύνη |
| accountability in spite of anonymity | ευθύνη ανεξαρτήτως της ύπαρξης ανωνυμίας |
| accountability with respect to a pseudonym | ευθύνη με βάση το ψευδώνυμου |
| acting entity | ενεργή Οντότητα |
| action | ενέργεια |
| addressable pseudonym | αναγνωρίσιμο Ψευδώνυμο |
| anonymity | ανωνυμία |
| anonymity set | σύνολο ανωνύμων οντοτήτων |
| anonymous | ανώνυμος |
| a-posteriori knowledge | μεταγενέστερη γνώση |
| application design | σχεδιασμός εφαρμογής |
| a-priori knowledge | προγενέστερη γνώση |
| attacker | επιτιθέμενος |
| attacker model | μοντέλο επιτιθέμενου |
| attribute | ιδιότητα/ χαρακτηριστικό |
| attribute authentication by third parties | αυθεντικοποίηση ιδιοτήτων από τρίτες οντότητες |
| attribute certificate | πιστοποιητικό ιδιότητας-χαρακτηριστικών |
| attribute values | τιμές ιδιοτήτων |
| authentication | αυθεντικοποίηση |
| avatar | αβατάρα |
| background knowledge | προγενέστερη γνώση |
| biometrics | βιομετρία |
| blocking | δέσμευση |
| broadcast | εκπομπή |
| certification authority | αρχή πιστοποίησης |
| chains of identity brokers | αλυσίδες μεσιτών ταυτοτήτων |
| change history | ιστορικό αλλαγών |
| civil identity | πολιτική ταυτότητα |
| communication network | δίκτυο επικοινωνίας |
| communication relationships | σχέσεις επικοινωνίας |

| | |
|---|---|
| complete identity | ολοκληρωμένη ταυτότητα |
| computer | υπολογιστής |
| context | περιεχόμενο |
| convertibility | μετατρεψιμότητα |
| convertibility of digital pseudonyms | μετατρεψιμότητα ψηφιακών ψευδωνύμων |
| cover claims | αξιώσεις κάλυψης |
| credential | διαπιστευτήρια |
| customer pseudonym | ψευδώνυμο πελάτη |
| data minimization | ελαχιστοποίηση δεδομένων |
| data protection regulations | κανονισμοί προστασίας δεδομένων |
| data subject | ενεργή οντότητα που περιέχει δεδομένα για προστασία |
| DC-net | DC-net |
| digital identity | ψηφιακή ταυτότητα |
| digital partial identity | στοιχείο έμμεσου προσδιορισμού της ταυτότητας |
| digital pseudonym | ψηφιακό ψευδώνυμο |
| digital signature | ψηφιακή υπογραφή |
| disinformation | παραπληροφόρηση |
| distinguish | διακρίνω |
| dummy traffic | περιττή κυκλοφορία |
| encryption | κρυπτογράφηση |
| end-to-end encryption | κρυπτογράφηση από-άκρο-σε-άκρο |
| entity | οντότητα |
| entropy | εντροπία |
| forget | ξεχνώ |
| globally unique pseudonym | συνολικά μοναδικό ψευδώνυμο |
| group communication | ομαδική επικοινωνία |
| group pseudonym | ομαδικό ψευδώνυμο |
| holder | κάτοχος |
| holder of the pseudonym | κάτοχος του ψευδώνυμου |
| human being | ανθρώπινη οντότητα |
| I | I |
| identifiability | αναγνωρισιμότητα |
| identifiability set | σύνολο αναγνωρίσιμων οντοτήτων |
| identifiable | αναγνωρίσιμος |
| identifier | προσδιοριστικό |
| identifier of a subject | προσδιοριστικό μιας ενεργής οντότητας |
| identity | ταυτότητα |
| identity broker | μεσίτης αποκάλυψης ταυτότητας |
| identity card | έντυπη ταυτότητα |
| identity certificate | πιστοποιητικό ταυτότητας |
| identity management | διαχείριση ταυτότητας |
| identity management application | εφαρμογή διαχείρισης ταυτότητας |
| identity management system | σύστημα διαχείρισης ταυτότητας |
| identity theft | κλοπή ταυτότητας |
| imply | υποδηλώνω |
| IMS | IMS |
| indistinguishability | δυσδιακρισία |
| indistinguishable | δυσδιάκριτος |
| individual | μεμονωμένος |
| initially non-public pseudonym | αρχικά μη-δημόσιο ψευδώνυμο |
| initially unlinked pseudonym | αρχικά μη-συνδέσιμο ψευδώνυμο |
| insider | εσωτερικός |
| introducer | εκκινών |
| is-a-person pseudonym | μοναδικό ψευδώνυμο ανά φυσικό πρόσωπο |
| items of interest | στοιχεία που ενδιαφέρουν |

| | |
|---|---|
| key | κλειδί |
| knowledge | γνώση |
| largest possible anonymity set | το δυνητικά μεγαλύτερο σύνολο ανωνυμίας |
| lattice | πλέγμα |
| legal person | νομικό πρόσωπο |
| liability broker | μεσίτης επίλυσης νομικών ζητημάτων |
| linkability | συνδεσιμότητα |
| linkability between the pseudonym and its holder | συνδεσιμότητα μεταξύ ψευδωνύμου και του κατόχου του |
| linkability broker | μεσίτης επίλυσης ζητημάτων συνδεσιμότητας |
| Me | εγώ |
| mechanisms | μηχανισμοί |
| mechanisms for anonymity | μηχανισμοί για ανωνυμία |
| mechanisms for unobservability | μηχανισμοί για μη-παρατηρησιμότητα |
| message | μήνυμα |
| message content | περιεχόμενο μηνύματος |
| misinformation | παραπληροφόρηση |
| MIX-net | MIX-net |
| mobile phone number | αριθμός κινητού τηλεφώνου |
| name | όνομα |
| natural person | φυσικό πρόσωπο |
| new knowledge | νέα γνώση |
| non-public pseudonym | μη-δημόσιο ψευδώνυμο |
| notice and choice | παρατηρώ και επιλέγω |
| nym | nym |
| nymity | nymity |
| observation | παρατήρηση |
| one-time pad | συμπληρωματικά δεδομένα μιας χρήσης |
| one-time-use pseudonym | ψευδώνυμο μιας χρήσης |
| organization | οργανισμός |
| outsider | εξωτερικός επιτιθέμενος |
| owner | ιδιοκτήτης |
| partial digital identity | στοιχείο έμμεσου προσδιορισμού της ταυτότητας |
| partial identity | μερική ταυτότητα |
| perfect secrecy | τέλεια μυστικότητα |
| person pseudonym | ψευδώνυμο φυσικού προσώπου |
| perspective | προοπτική, θεώρηση |
| precise | ακριβής |
| privacy | ιδιωτικότητα |
| privacy-enhancing application design | σχεδίαση εφαρμογών ενίσχυσης της ιδιωτικότητας |
| privacy-enhancing identity management system | σύστημα διαχείρισης ταυτότητας που ενισχύει την ιδιωτικότητα |
| Privacy-Enhancing Technologies | τεχνολογίες ενίσχυσης της Ιδιωτικότητας |
| private information retrieval | ανάκτηση ιδιωτικών πληροφοριών |
| private key | ιδιωτικό κλειδί |
| probabilities | πιθανότητες |
| property | ιδιότητα |
| pseudonym | ψευδώνυμο |
| pseudonymity | ψευδωνυμία |
| pseudonymization | η διαδικασία της ψευδωνυμίας |
| pseudonymous | η κατάσταση ενός χρήστη που χρησιμοποιεί ψευδώνυμο |
| public key | δημόσιο κλειδί |
| public key certificate | πιστοποιητικό δημοσίου κλειδιού |
| public pseudonym | δημόσιο ψευδώνυμο |
| quality of anonymity | ποιότητα ανωνυμίας |

| | |
|---|---|
| quantify pseudonymity | ποσοτικοποιώ τη ψευδωνυμία |
| quantify unlinkability | ποσοτικοποιώ τη μη-συνδεσιμότητα |
| quantify unobservability | ποσοτικοποιώ τη μη- παρατηρησιμότητα |
| quantity of anonymity | ποσότητα ανωνυμίας |
| real name | πραγματικό όνομα |
| recipient | παραλήπτης |
| recipient anonymity | ανωνυμία του παραλήπτη |
| recipient anonymity set | σύνολο ανωνύμων παραληπτών |
| recipient pseudonymity | ψευδωνυμία του παραλήπτη |
| recipient unobservability | μη- παρατηρησιμότητα του παραλήπτη |
| recipient unobservability set | σύνολο μη- παρατηρήσιμων παραληπτών |
| relationship anonymity | ανωνυμία σχέσης |
| relationship anonymity set | σύνολο ανωνύμων σχέσεων |
| relationship pseudonym | ψευδωνυμία σχέσης |
| relationship unobservability | μη-παρατηρησιμότητα σχέσης |
| relationship unobservability set | σύνολο μη-παρατηρήσιμων σχέσεων |
| relative unlinkability | μη τροποποίηση υπάρχουσας γνώσης σχετικά με τη διασυνδεσιμότητα μεταξύ χρηστών |
| reputation | φήμη |
| revocation | ανάκληση |
| robustness of anonymity | ρωμαλεότητα ανωνυμίας |
| role | ρόλος |
| role pseudonym | ψευδώνυμο ρόλου |
| role-relationship pseudonym | ψευδώνυμο ρόλου-σχέσης |
| semantic dummy traffic | σημασιολογικά περιττή κυκλοφορία |
| sender | αποστολέας |
| sender anonymity | ανωνυμία αποστολέα |
| sender anonymity set | σύνολο ανωνυμιών αποστολέων |
| sender pseudonymity | ψευδωνυμία του αποστολέα |
| sender unobservability | μη- παρατηρησιμότητα του αποστολέα |
| sender unobservability set | σύνολο μη- παρατηρήσιμων αποστολέων |
| sender-recipient-pairs | ζεύγη αποστολέα-παραλήπτη |
| set | σύνολο |
| set of subjects | σύνολο ενεργών οντοτήτων |
| setting | περιβάλλον |
| side channel | δίαυλος παράπλευρων πληροφοριών |
| social role | κοινωνικός ρόλος |
| social security number | αριθμός κοινωνικής ασφάλισης |
| spread spectrum | φάσμα |
| state | κατάσταση |
| steganographic systems | συστήματα στεγανογραφίας |
| steganography | στεγανογραφία |
| strength of anonymity | ισχύς της ανωνυμίας |
| subject | ενεργή οντότητα |
| surrounding | περιβάλλον |
| system | σύστημα |
| transaction pseudonym | ψευδώνυμο δοσοληψίας |
| transfer of holdership | μεταφορά ιδιοκτησίας |
| transferability | δυνατότητα μεταβίβασης |
| transferable group pseudonym | μεταβιβάσιμο ομαδικό ψευδώνυμο |
| transferable pseudonym | μεταβιβάσιμο ψευδώνυμο |
| undetectability | μη-ανιχνευσιμότητα |
| uniqueness | μοναδικότητα |
| universe | κόσμος |
| unlinkability | μη- συνδεσιμότητα |
| unobservability | μη- παρατηρησιμότητα |

| | |
|---|---|
| unobservability set | σύνολο μη- παρατηρήσιμων οντοτήτων |
| user-controlled linkage | σύστημα σύνδεσης ελεγχόμενο από το χρήστη |
| user-controlled release | σύστημα αποσύνδεσης ελεγχόμενο από το χρήστη |
| usual suspects | συνήθεις ύποπτοι |
| value broker | μεσίτης προσδιορισμού αξίας |
| virtual identity | εικονική ταυτότητα |
| zero-knowledge proof | απόδειξη μηδενικής γνώσης |

**To Italian**

Dr. Giovanni Baruzzi, Syntlogo GmbH
giovanni.baruzzi@syntlogo.de

Dr. Giuseppe Palumbo, Univ. Modena, Italy
gpalumbo@unimore.it

| | |
|---|---|
| absolute anonymity | anomimato assoluto |
| absolute unlinkability | non-collegabilità assoluta |
| abuse | abuso |
| accountability | responsabilità |
| accountability in spite of anonymity | responsabilità malgrado l'anonimato |
| accountability with respect to a pseudonym | responsabilità relativa a uno pseudonimo |
| acting entity | entità agente |
| action | azione |
| addressable pseudonym | pseudonimo indirizzabile |
| anonymity | anonimato |
| anonymity set | insieme anonimo |
| anonymous | anonimo |
| a-posteriori knowledge | conoscenza a posteriori |
| application design | progettazione di applicazioni |
| a-priori knowledge | conoscenza a priori |
| attacker | attaccante |
| attacker model | modello di attacco |
| attribute | attributo |
| attribute authentication by third parties | autentica di attributi da parte di terzi |
| attribute certificate | certificato attributivo |
| attribute values | valori dell'attributo |
| authentication | autenticazione |
| avatar | avatar |
| background knowledge | conoscenze pregresse |
| biometrics | biometria |
| blocking | blocco |
| broadcast | broadcast, trasmissione a largo raggio |
| certification authority | autorità di certificazione |
| chains of identity brokers | catene di intermediari di certificazione |
| change history | storia delle variazioni |
| civil identity | identità civile |
| communication network | rete di comunicazione |
| communication relationships | relazioni di comunicazione |
| complete identity | identità completa |
| computer | calcolatore, computer |
| context | contesto |

| | |
|---|---|
| convertibility | convertibilità |
| convertibility of digital pseudonyms | convertibilità di pseudonimi digitali |
| cover claims | coprire i rischi, copertura di rischi |
| credential | credenziali |
| customer pseudonym | pseudonimo cliente |
| data minimization | minimizzazione dei dati |
| data protection regulations | normativa sulla protezione dei dati |
| data subject | soggetto-dati |
| DC-net | DC-net |
| digital identity | identità digitale |
| digital partial identity | identità digitale parziale |
| digital pseudonym | pseudonimo digitale |
| digital signature | firma digitale |
| disinformation | informazioni fuorvianti |
| distinguish | distinguere |
| dummy traffic | traffico dummy, traffico fasullo |
| encryption | cifratura |
| end-to-end encryption | cifratura end-to-end |
| entity | entità |
| entropy | entropia |
| forget | dimenticare |
| globally unique pseudonym | pseudonimo globalmente unico |
| group communication | comunicazione di gruppo |
| group pseudonym | pseudonimo di gruppo |
| holder | possessore |
| holder of the pseudonym | possessore dello pseudonimo |
| human being | essere umano |
| I | Io |
| identifiability | identificabilità |
| identifiability set | insieme di identificabilità |
| identifiable | identificabile |
| identifier | identificatore |
| identifier of a subject | identificatore di un soggetto |
| identity | identità |
| identity broker | intermediario di identità |
| identity card | carta d'identità |
| identity certificate | certificato d'identità |
| identity management | gestione delle identità |
| identity management application | applicazione di gestione delle identità |
| identity management system | sistema di gestione delle identità |
| identity theft | furto d'identità |
| imply | implica |
| IMS | Identity Management System: sistema di gestione delle identità |
| indistinguishability | indistinguibilità |
| indistinguishable | indistinguibile |
| individual | individuo |
| initially non-public pseudonym | pseudonimo inizialmente non pubblico |
| initially unlinked pseudonym | pseudonimo inizialmente non collegato |
| insider | Insider, entità che agisce dall’interno |
| introducer | introduttore, utente |
| is-a-person pseudonym | pseudonimo di persona naturale, pseudonimo individuale |
| items of interest | elementi di interesse |
| key | chiave |
| knowledge | conoscenza |

| | |
|---|---|
| largest possible anonymity set | il più grande degli insiemi anonimi |
| lattice | reticolo |
| legal person | persona giuridica |
| liability broker | intermediario di responsabilità |
| linkability | collegabilità |
| linkability between the pseudonym and its holder | collegabilità tra lo pseudonimo e il suo possessore |
| linkability broker | intermediario di collegabilità |
| Me | me |
| mechanisms | meccanismo |
| mechanisms for anonymity | meccanismo per l'anonimato |
| mechanisms for unobservability | meccanismi per l'inosservabilità |
| message | messaggio |
| message content | contenuto del messaggio |
| misinformation | informazioni sbagliate |
| MIX-net | MIX-net |
| mobile phone number | numero di telefono cellulare |
| name | nome |
| natural person | persona naturale |
| new knowledge | nuova conoscenza |
| non-public pseudonym | pseudonimo non pubblico |
| notice and choice | avviso e scelta (principio secondo cui un utente deve essere informato e deve poter scegliere circa il trattamento dei dati) |
| nym | nym, nomignolo, pseudonimo |
| nymity | nymity, pseudonomia, |
| observation | osservazione |
| one-time pad | blocco appunti monouso |
| one-time-use pseudonym | pseudonimo monouso |
| organization | organizzazione |
| outsider | outsider / osservatore esterno |
| owner | proprietario |
| partial digital identity | identità digitale parziale |
| partial identity | identità parziale |
| perfect secrecy | segretezza perfetta |
| person pseudonym | pseudonimo di persona |
| perspective | prospettiva |
| precise | preciso |
| privacy | privacy, riservatezza |
| privacy-enhancing application design | progetto di applicazioni atte a migliorare la tutela della privacy |
| privacy-enhancing identity management system | sistema di gestione delle identità atto a migliorare la tutela della privacy |
| Privacy-Enhancing Technologies | tecnologie per la tutela della privacy |
| private information retrieval | reperimento di informazioni private |
| private key | chiave privata |
| probabilities | probabilità |
| property | proprietà |
| pseudonym | pseudonimo |
| pseudonymity | pseudonomia |
| pseudonymization | pseudonomizzazione |
| pseudonymous | pseudonimo (sic!) |
| public key | chiave pubblica |
| public key certificate | certificato a chiave pubblica |
| public pseudonym | pseudonimo pubblico |
| quality of anonymity | qualità dell'anonimato |

| | |
|---|---|
| quantify pseudonymity | quantificazione della pseudonomia |
| quantify unlinkability | quantificazione della non-collegabilità |
| quantify unobservability | quantificazione della inosservabilità |
| quantity of anonymity | quantità di anonimato |
| real name | vero nome |
| recipient | destinatario |
| recipient anonymity | anonimato del destinatario |
| recipient anonymity set | insieme anonimo dei destinatari |
| recipient pseudonymity | pseudonimia del destinatario |
| recipient unobservability | inosservabilità del destinatario |
| recipient unobservability set | insieme dell'inosservabilità del destinatario |
| relationship anonymity | anonimato di relazione |
| relationship anonymity set | <Your input needed> |
| relationship pseudonym | pseudonimo di relazione |
| relationship unobservability | inosservabilità della relazione |
| relationship unobservability set | <Your input needed> |
| relative unlinkability | non-collegabilità relativa |
| reputation | reputazione |
| revocation | revoca |
| robustness of anonymity | robustezza dell'anonimato |
| role | ruolo |
| role pseudonym | pseudonimo di ruolo |
| role-relationship pseudonym | pseudonimo di ruolo-relazione |
| semantic dummy traffic | traffico fasullo semantico |
| sender | mittente |
| sender anonymity | anonimato del  mittente |
| sender anonymity set | insieme di anonimato del mittente |
| sender pseudonymity | pseudonimia del mittente |
| sender unobservability | inosservabilità del mittente |
| sender unobservability set | insieme di inosservabilità del mittente |
| sender-recipient-pairs | coppie mittente-destinatario |
| set | insieme |
| set of subjects | insieme di soggetti |
| setting | scenario |
| side channel | canale laterale |
| social role | ruolo sociale |
| social security number | "numero della sicurezza sociale", better: codice fiscale |
| spread spectrum | spettro espanso |
| state | stato |
| steganographic systems | sistemi steganografici |
| steganography | steganografia |
| strength of anonymity | forza dell’anonimato |
| subject | soggetto |
| surrounding | circostante |
| system | sistema |
| transaction pseudonym | pseudonimo di transazione |
| transfer of holdership | trasferimento di possesso |
| transferability | trasferibilità |
| transferable group pseudonym | pseudonimo di gruppo trasferibile |
| transferable pseudonym | pseudonimo trasferibile |
| undetectability | <Your input needed> |
| uniqueness | unicità |
| universe | universo |
| unlinkability | non-collegabilità |
| unobservability | inosservabilità |

| | |
|---|---|
| unobservability set | insieme di inosservabilità |
| user-controlled linkage | collegamento controllato dall'utente |
| user-controlled release | rilascio controllato dall'utente |
| usual suspects | soliti sospetti |
| value broker | intermediario di valore |
| virtual identity | identità virtuale |
| zero-knowledge proof | prova di non conoscenza |

**To <your mother tongue>**
<your name and e-mail address>

| | |
|---|---|
| absolute anonymity | <Your input needed> |
| absolute unlinkability | <Your input needed> |
| abuse | <Your input needed> |
| accountability | <Your input needed> |
| accountability in spite of anonymity | <Your input needed> |
| accountability with respect to a pseudonym | <Your input needed> |
| acting entity | <Your input needed> |
| action | <Your input needed> |
| addressable pseudonym | <Your input needed> |
| anonymity | <Your input needed> |
| anonymity set | <Your input needed> |
| anonymous | <Your input needed> |
| a-posteriori knowledge | <Your input needed> |
| application design | <Your input needed> |
| a-priori knowledge | <Your input needed> |
| attacker | <Your input needed> |
| attacker model | <Your input needed> |
| attribute | <Your input needed> |
| attribute authentication by third parties | <Your input needed> |
| attribute certificate | <Your input needed> |
| attribute values | <Your input needed> |
| authentication | <Your input needed> |
| avatar | <Your input needed> |
| background knowledge | <Your input needed> |
| biometrics | <Your input needed> |
| blocking | <Your input needed> |
| broadcast | <Your input needed> |
| certification authority | <Your input needed> |
| chains of identity brokers | <Your input needed> |
| change history | <Your input needed> |
| civil identity | <Your input needed> |
| communication network | <Your input needed> |
| communication relationships | <Your input needed> |
| complete identity | <Your input needed> |
| computer | <Your input needed> |
| context | <Your input needed> |
| convertibility | <Your input needed> |
| convertibility of digital pseudonyms | <Your input needed> |
| cover claims | <Your input needed> |
| credential | <Your input needed> |
| customer pseudonym | <Your input needed> |
| data minimization | <Your input needed> |
| data protection regulations | <Your input needed> |

| | |
|---|---|
| data subject | <Your input needed> |
| DC-net | <Your input needed> |
| digital identity | <Your input needed> |
| digital partial identity | <Your input needed> |
| digital pseudonym | <Your input needed> |
| digital signature | <Your input needed> |
| disinformation | <Your input needed> |
| distinguish | <Your input needed> |
| dummy traffic | <Your input needed> |
| encryption | <Your input needed> |
| end-to-end encryption | <Your input needed> |
| entity | <Your input needed> |
| entropy | <Your input needed> |
| forget | <Your input needed> |
| globally unique pseudonym | <Your input needed> |
| group communication | <Your input needed> |
| group pseudonym | <Your input needed> |
| holder | <Your input needed> |
| holder of the pseudonym | <Your input needed> |
| human being | <Your input needed> |
| I | <Your input needed> |
| identifiability | <Your input needed> |
| identifiability set | <Your input needed> |
| identifiable | <Your input needed> |
| identifier | <Your input needed> |
| identifier of a subject | <Your input needed> |
| identity | <Your input needed> |
| identity broker | <Your input needed> |
| identity card | <Your input needed> |
| identity certificate | <Your input needed> |
| identity management | <Your input needed> |
| identity management application | <Your input needed> |
| identity management system | <Your input needed> |
| identity theft | <Your input needed> |
| imply | <Your input needed> |
| IMS | <Your input needed> |
| indistinguishability | <Your input needed> |
| indistinguishable | <Your input needed> |
| individual | <Your input needed> |
| initially non-public pseudonym | <Your input needed> |
| initially unlinked pseudonym | <Your input needed> |
| insider | <Your input needed> |
| introducer | <Your input needed> |
| is-a-person pseudonym | <Your input needed> |
| items of interest | <Your input needed> |
| key | <Your input needed> |
| knowledge | <Your input needed> |
| largest possible anonymity set | <Your input needed> |
| lattice | <Your input needed> |
| legal person | <Your input needed> |
| liability broker | <Your input needed> |
| linkability | <Your input needed> |
| linkability between the pseudonym and its holder | <Your input needed> |
| linkability broker | <Your input needed> |
| Me | <Your input needed> |
| mechanisms | <Your input needed> |

| | |
|---|---|
| mechanisms for anonymity | <Your input needed> |
| mechanisms for unobservability | <Your input needed> |
| message | <Your input needed> |
| message content | <Your input needed> |
| misinformation | <Your input needed> |
| MIX-net | <Your input needed> |
| mobile phone number | <Your input needed> |
| name | <Your input needed> |
| natural person | <Your input needed> |
| new knowledge | <Your input needed> |
| non-public pseudonym | <Your input needed> |
| notice and choice | <Your input needed> |
| nym | <Your input needed> |
| nymity | <Your input needed> |
| observation | <Your input needed> |
| one-time pad | <Your input needed> |
| one-time-use pseudonym | <Your input needed> |
| organization | <Your input needed> |
| outsider | <Your input needed> |
| owner | <Your input needed> |
| partial digital identity | <Your input needed> |
| partial identity | <Your input needed> |
| perfect secrecy | <Your input needed> |
| person pseudonym | <Your input needed> |
| perspective | <Your input needed> |
| precise | <Your input needed> |
| privacy | <Your input needed> |
| privacy-enhancing application design | <Your input needed> |
| privacy-enhancing identity management system | <Your input needed> |
| Privacy-Enhancing Technologies | <Your input needed> |
| private information retrieval | <Your input needed> |
| private key | <Your input needed> |
| probabilities | <Your input needed> |
| property | <Your input needed> |
| pseudonym | <Your input needed> |
| pseudonymity | <Your input needed> |
| pseudonymization | <Your input needed> |
| pseudonymous | <Your input needed> |
| public key | <Your input needed> |
| public key certificate | <Your input needed> |
| public pseudonym | <Your input needed> |
| quality of anonymity | <Your input needed> |
| quantify pseudonymity | <Your input needed> |
| quantify unlinkability | <Your input needed> |
| quantify unobservability | <Your input needed> |
| quantity of anonymity | <Your input needed> |
| real name | <Your input needed> |
| recipient | <Your input needed> |
| recipient anonymity | <Your input needed> |
| recipient anonymity set | <Your input needed> |
| recipient pseudonymity | <Your input needed> |
| recipient unobservability | <Your input needed> |
| recipient unobservability set | <Your input needed> |
| relationship anonymity | <Your input needed> |
| relationship anonymity set | <Your input needed> |
| relationship pseudonym | <Your input needed> |

| | |
|---|---|
| relationship unobservability | <Your input needed> |
| relationship unobservability set | <Your input needed> |
| relative unlinkability | <Your input needed> |
| reputation | <Your input needed> |
| revocation | <Your input needed> |
| robustness of anonymity | <Your input needed> |
| role | <Your input needed> |
| role pseudonym | <Your input needed> |
| role-relationship pseudonym | <Your input needed> |
| semantic dummy traffic | <Your input needed> |
| sender | <Your input needed> |
| sender anonymity | <Your input needed> |
| sender anonymity set | <Your input needed> |
| sender pseudonymity | <Your input needed> |
| sender unobservability | <Your input needed> |
| sender unobservability set | <Your input needed> |
| sender-recipient-pairs | <Your input needed> |
| set | <Your input needed> |
| set of subjects | <Your input needed> |
| setting | <Your input needed> |
| side channel | <Your input needed> |
| social role | <Your input needed> |
| social security number | <Your input needed> |
| spread spectrum | <Your input needed> |
| state | <Your input needed> |
| steganographic systems | <Your input needed> |
| steganography | <Your input needed> |
| strength of anonymity | <Your input needed> |
| subject | <Your input needed> |
| surrounding | <Your input needed> |
| system | <Your input needed> |
| transaction pseudonym | <Your input needed> |
| transfer of holdership | <Your input needed> |
| transferability | <Your input needed> |
| transferable group pseudonym | <Your input needed> |
| transferable pseudonym | <Your input needed> |
| undetectability | <Your input needed> |
| uniqueness | <Your input needed> |
| universe | <Your input needed> |
| unlinkability | <Your input needed> |
| unobservability | <Your input needed> |
| unobservability set | <Your input needed> |
| user-controlled linkage | <Your input needed> |
| user-controlled release | <Your input needed> |
| usual suspects | <Your input needed> |
| value broker | <Your input needed> |
| virtual identity | <Your input needed> |
| zero-knowledge proof | <Your input needed> |