Towards an Open and Heterogeneous Social Web

Sebastian Göndör
Telekom Innovation Laboratories / TU Berlin, Service-centric Networking
Berlin, Germany
sebastian.goendoer@tu-berlin.de

ABSTRACT

Online Social Networks (OSN) have become an integral part of our everyday lives. We express ourselves, share content and information with our friends and colleagues, or exchange messages. Yet, despite social communication being implicitly a distributed, decentralized way of information exchange that does not require any central entity to supervise the process, most OSN services are built in a central, monolithic fashion. This contradicts the idea of the social web, as proprietary and isolated walled gardens keep users from being able to freely choose an OSN platform provider or to effectively control their privacy. To enable users of the social web to remain in control of their social profiles and data, solutions were proposed that allow hosting one's social profile on independent servers, which then connect to each other in a loosely coupled fashion. Unfortunately, implicit network effects existing in large OSN services prevent users from migrating to alternative solutions thus ultimately hindering alternative OSN services to succeed in the social web. In this paper, we outline the main challenges that need to be addressed in order to allow decentralized OSN services to become real alternatives to well-established services such as Facebook or Twitter. The identified main challenges are coverage of typical, standard OSN functionality, a holistic and extensible interoperability protocol, support for data portability of entire social profiles, and support for platform-independent user identification. The paper then outlines Sonic, an open architecture for an open and heterogeneous network of independent OSN services, the Online Social Network Federation (OSNF), in which the identified challenges are addressed altogether.

CCS CONCEPTS

• **Information systems → Social networks**;

KEYWORDS

Social Web, Online Social Networks, Decentralization, Interoperability, Data Portability

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1 INTRODUCTION

The current situation of the social web can be characterized as a landscape of different, individual OSN services designed as isolated data silos [18][37]. These silos are isolated from each other by the use of proprietary APIs, protocols, and data formats. Users are therefore not able to connect to each other across platform borders. In consequence, users of OSN services tend to have multiple accounts in order to be able to keep in touch with friends in different OSN services [26], resulting in an overlap of information [4]. Yeung et al. note that given that OSN services are preventing interconnectivity with competing services, users *"would like to 'jump out of the walled gardens' [...] to share their data with their friends who may be members of other social networking sites."* [37]. After all, social communication and collaboration is, by its own nature, peer to peer and not centralized [24]. In the envisioned decentralized social web, users would not be restricted to the OSN service they signed up with in the first place anymore [37].

With the aim to *"build their own social web"* [11], programmers and researchers proposed alternatives to the closed, proprietary silos, driven by the belief that *"a truly universal, open, and distributed social web architecture is needed"* [1] and that the Internet needed *"a way to take the features of the popular social networks and make them available to the world at large"* [11]. Applequist et al. identified four major problems for users of closed OSN services, being the ability to move social profile data between OSN services (portability), using one identity across the entire social web instead of separated ones (identity), the ability to link to social profiles and data from outside the OSN service storing this data (linkability), and being in control over access and use of one's social profile data (privacy) [1]. They proposed an approach for a *"standards-based, open and privacy-aware social web"*, in which users would own and control their social profile data in a trusted location while disclosing selected parts of it to selected OSN services. This way, online personas could be created with different scopes, for example for personal and professional use, where only content suitable for the respective persona would be accessible in the respective OSN service [1]. Still, this approach would require users to sign up with multiple OSN services, where data is replicated to the connected social profiles [24], a practice that users are *"sick of"* [9]. In today's social web, users demand privacy and control over their data while at the same time not being willing to give up on usability and ease-of-use.

While proposing alternative architectures to address network and lock-in effects [34], researchers acknowledged that a major challenge of DOSN services is adoption by users [37]. Applequist et al. state that *"participation is the life blood of social networks. If [...] too few people participate, a social networking application dies"* [1]. As found by Westland [35], OSN services experience network effects after they reached a critical mass of participating users. According to perlocation theory, at this point a phase change happens in the

social graph and a giant cluster of users forms in the network [35]. An OSN then becomes self-sustaining and is able to attract even more users for the simple reason that most likely, most of the friends, relatives, or acquaintances of a certain user are already using the OSN service in question. Hence, a user is not free anymore in his choice of an OSN service and has to sign up with the dominant OSN service as otherwise, he would be cut off from the rest of the social web. As a result, OSN services that manage to achieve a certain critical mass of users as the first service in the market massively benefit from implicit network effects and are therefore able to easily dominate the market [35].

To alleviate the situation and give back control to users, various alternative OSN services where proposed many of which decentralize functionality and data storage to multiple independent servers. Still, as analyzed by Göndör and Küpper [15], the proposed solutions are mostly built based on mutually incompatible protocols and data formats. In consequence, existing decentralized OSN services fail to seamlessly interconnect to each other and therefore lock-in their users in yet another walled garden [15], a result of multiple mutually incompatible protocols and standards and mostly lacking technical specification and documentation of the protocols and formats they implement.

To propose a holistic solution for today's social web of isolated islands, this work discusses challenges for a decentralized and heterogeneous social web. The project *SOcial Network InterConnect*[1] (Sonic) aims to bring forward a heterogeneous and open federation of mutually independent OSN services, which support full interoperability based on a common set of protocols and data formats [12]. In this paper, we outline the main challenges of today's social web that allow arbitrary OSN services to connect to each other as depicted in Figure 1. As a result, an open and heterogeneous Online Social Network Federation (OSNF) forms, which is defined as a *"heterogeneous network of loosely coupled OSN platforms using a common set of protocols and data formats in order to allow seamless communication and interoperability between different OSN platforms"* [14].

The remainder of this paper is organized as follows. Section 2 lists requirements and challenges for services in a decentralized and open social web as already stated in scientific literature. Based on an analysis of the situation of today's social web, Section 3 lists challenges the social web has to tackle. Section 4 then outlines the vision of an open and heterogeneous social web, in which different OSN platforms connect to each other. Section 5 concludes the paper and gives an overview of future work for the decentralized social web.

[1]Sonic webpage: http://sonic-project.net

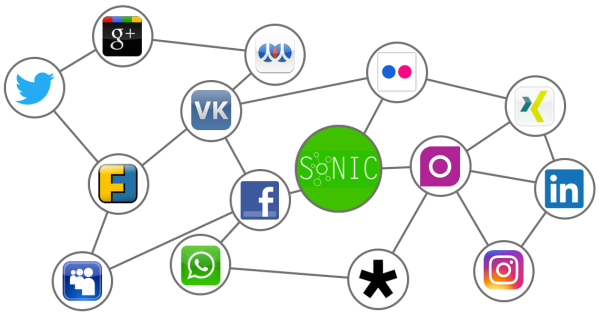

Figure 1: In an OSNF, arbitrary OSN services are connected to each other in a loosely coupled fashion. A holistic interoperability standard ensures that users of different OSN platforms can seamlessly connect to each other.

2 RELATED WORK

To address the issues of centralization and lack of control for users of today's social web, Fitzpatrick and Recordon defined in their much-noticed article *Thoughts on the Social Graph* several goals, including to *"make the social graph a community asset [...]"*, namely by establishing a *"[...] non-profit and open source software"* ensuring *"[...] that the design [of components] is such that others can run their own instances, sharing data with each other"* [9]. While many alternative OSN architectures and services were proposed [17][10][25], user numbers of alternative OSN services remain very low to this day.In their survey of decentralized OSN services [29], Paul et al. defined a list of requirements for services in a decentralized social web. First, Paul et al. note that *transparency* of the decentralized architecture is required in order to allow inexpert audiences to use the service. Furthermore, all functionality must be accessible via a *single integrating interface* must be provided, rendering platform borders irrelevant. At the same time, all data-related *functionality* of OSN services need to be supported, including creating and maintaining *relations* to other users. Finally, Paul et al. note that *confidentiality*, *access control*, and *privacy* need to be ensured for users and their data.

Koll et al. also analyzed factors of success of decentralized OSN (DOSN) services in their survey [24] and provided a list of nine challenges DOSN services have to accomplish in order to be successful in the market. Challenges addressing the general architecture of decentralized OSN services include that all parts of an OSN service must remain *independent* from any central entity, while providing the service *free of charge*. Furthermore, OSN services need to *available at all times* and allow users to use it exclusively using *mobile devices*. Koll et al. further note that *efficiency* in terms of communication overhead, *scalability* to millions of users, and *resiliency* against attacks and network dynamics are important requirements and need to be ensured while providing an at least *user-friendly performance*. Finally, Koll et al. note that *privacy* and *usability* need to be ensured to not scare off potential users.

Koll et al. argue that while an ideal DOSN service would satisfy all listed challenges, some of them are rather mutually exclusive [24]. Hence, a balanced compromise needs to be found for a DOSN service to be successful. For example, independence of external resource providers and efficiency are hard to satisfy at the same time, as a central system is able to prevent communication overhead far better than a decentralized one. Hence, a DOSN service can either reduce communication overhead or dependence on (central) providers. Other examples are that performance and high availability is financially hard to achieve when the service is free of charge for its users, and that privacy control prevents business models as employed by Facebook. Koll et al. conclude that a distributed, federated approach where social profiles and associated data is

hosted on a user's home gateway provides the best option to build a successful DOSN service [24], where the feasibility of this approach has been proven by Marcon et al. in [27].

The situation of a social web consisting of closed, proprietary walled gardens has also been addressed by European law. In an analysis of European regulatory and competition law issues, Graef argues that OSN services are mainly multi-sided businesses with users on the one and advertisers on the other side, as indirect network effects between users and advertisers can be clearly identified [16]. These indirect network effects, as described by Katz and Shapiro [23], result in an increased utility of the service for customers as the overall number of consumers of the service increases. In case of OSN services, a higher number of users results in an increased value of the service for advertising companies, as more users can be reached by publishing advertisements in the OSN service. Graef further notes that OSN markets are *"[...] typically quite concentrated, since it is necessary to have a critical mass of customers"* to be able to succeed in the market, making it *"[...] difficult for competing platforms to gain a foothold in the [OSN] market"*, what ultimately tends to *"[...] limit the number of viable firms in a market"* [16]. Following the European Court of Justice's definition of dominance, being *"a position of economic strength enjoyed by an undertaking which enables it to prevent effective competition being maintained on the relevant market by giving it the power to behave to an appreciable extend independently of its competitors, customers, and ultimately of its consumers"* [7], Graef sees Facebook in a dominant market position, effectively hindering competitors being successful in the OSN market. Seeing OSN services as communication platforms, Graef argues that legal action should ensure that competition is made possible again. To alleviate the current situation of one OSN platform dominating the entire OSN market, Graef proposes to mandate regulatory action based on European competition laws where two aspects should be addressed in specific, being data portability and interoperability.

Graef describes data portability in the domain of OSN services as a user's ability to automatically move their social profile data including photos, posts, and friend lists to a competitor's service, where *"technical standards have to be developed to ensure that data portability can be effectively implemented [...]"* so that *"it [is] possible for data extracted from one social network to be seamlessly inserted into another [OSN service]"* [16]. Yet, data portability as proposed in the General Data Protection Regulation of the European Commission merely grants the extraction and transfer of data that would allow to identify a user and would therefor not necessarily allow users to transfer all social profile data to a competitor's OSN platform. Graef argues hence that regulation is necessary to ensure interoperability is implemented, giving users the ability to *"[...] connect and interact with each other irrespective of their social network provider"* [16], thus being even more powerful than data portability alone. Graef argues that implementing OSN network interoperability would be *"a way to redress network effects and increase competition in the [OSN] market [...]"* furthermore reducing *"[...] switching costs and the degree of user lock-in [...]"* as *"[...] the number of people that a user can reach is not limited anymore to the number of users on the social network that the user decided to join"* [16]. Furthermore, Graef states that *"[...] interconnection requirements should be imposed in general on all social networks and in all situations"* as *"real interoperability can only be established when all social network providers are obliged to participate in the process"* [16]. Finally, Graef notes that mandating support for data portability and interoperability may affect the business models of OSN services, yet will encourage new services to enter the market, leading to more and healthy competition and consumer choice, and will ultimately result in a better protection of the rights and interests of users of OSN services [16]. As of 2016, data portability has been regulated in the General Data Protection Regulation (GDPR) by the European Union (EU) [8]. The regulation addresses a mandatory ability to export personal information *"[...] in a structured, commonly used, machine-readable, and interoperable format [...]"* including the ability to transmit the exported information to other services. With the intention to *"further strengthen the control"* over one's data, the regulation is enforceable as of May 2018, yet lacks a technical implementation of how data should be exported, described, or re-imported. As pointed out by Sperlich [33], this creates technical challenges, as service providers mostly use proprietary data formats which are tailored to the individual data processing systems with the intention to create lock-in effects for customers.

3 OPEN CHALLENGES FOR AN OPEN AND HETEROGENEOUS SOCIAL WEB

In order for an open and heterogeneous federation of OSN services to be implemented, several challenges have to be tackled. These challenges are the definition of a core featureset for OSN services, definition of an extensible interoperability protocol, means for a global and domain-agnostic user- and content identification, as well as support for seamless data portability for entire social profiles between the different OSN services in the federation.

3.1 Definition of a Core Featureset of OSN Platforms

Existing implementations of OSN services vary in functionality covered as well as implementation specifics o these features. In the highly competitive OSN market [16], OSN services are required to compete for users to sign up with their service rather than with a competitor's platform. OSN services therefore implement a variety of features and functionality in order to follow the latest trends and keep up with competitors [36]. Still, even though the supported featuresets differ between individual OSN service implementations one can identify a set of basic core functionality, which usually does not differ much from the implementations of other OSN services. Such features comprise for example profile pages, messaging functionality, or liking content of other users. While the individual feature implementations may differ in details, such as the extent of a profile page, or connections to friends being uni- or bidirectional, the underlying functionality remains the same. To allow the definition of a common social protocol and set of data formats, a taxonomy for features of OSN services is required from which a core featureset of OSN functionality can be derived. The features comprised by such a core featureset are supported by almost all existing OSN implementations, while implementation details rarely diverge. Therefore, such a core featureset would comprise all common functionality of today's social web and could therefore be used

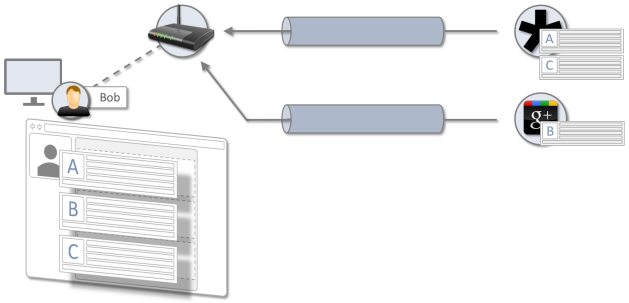

Figure 2: Communication between different servers. Content is fetched from remote servers using the interoperability protocol and then displayed in a single integrating view. Content is encoded using standard data formats.

by developers to create solutions with state-of-the-art functionality. To support features not comprised by such a core featureset, individually created feature implementations should be able to be integrated into OSN services via built-in support for extensibility. This would allow OSN service implementations to create a unique user experience by providing unique additional features to their users.

3.2 OSN Interoperability Protocol

Even though a variety of data standards and protocol exist that address communication and data exchange in the social web [1][19], a holistic approach that facilitates seamless communication between different OSN service implementations does not exist. Existing solutions focus on mostly isolated issues and tasks, such as describing activities [6], discovery of user profiles [22], or modeling links between users [3]. A holistic communication standard that comprises data formats as well as APIs with the objective to allow seamless exchange of data between different OSN service implementations is hence required. Following this approach, as depicted in Figure 2, data from other, possibly remote, social profiles can be fetched to be displayed in the user interface of one's own OSN service. This way, platform borders will be rendered entirely transparent to users.

Data formats of such a communication standard should be implemented to be compatible with existing microstandards such as Activity Streams 2.0 [21], Open Social [20], or OStatus [31] in order to ensure easy integration in existing as well as new OSN service implementations. In order to support not only functionality described by the core featureset but also extended functionality, an OSN interoperability protocol needs to be extensible. Similar to extensibility implemented in XMPP [32], extensibility of an OSN interoperability protocol would allow OSN service implementations to implement individual features that can then be used by all users of OSN services supporting the same functionality. The interoperability protocol would therefore need to support functionality for feature discovery in order to discover the supported feature extensions of a platform. This would enable OSN services to communicate using a broad variety of functionality.

3.3 Data Portability for User Accounts

The well calculated lock-in effects of today's centralized OSN platforms keep users from moving their social profile to a competitor's service even in cases where a user might want to switch to another OSN service. In consequence, users who are not satisfied anymore with their current OSN service or its terms of usage cannot move to a competitor's service without losing all their social profile data and connections to other users. The use of open DOSN architectures such as federated or P2P-based approaches cannot solve this issue, as a user would again be caught within the boundaries of one of these architecture due to the mutually mostly incompatible communication protocols used [15]. Without the means to freely move a social profile to any other OSN platform, federated approaches still lock the user into their domain. Mere copying of a user's profile data to a new location would not suffice, as a user's identifier would still point to the old and invalid location of that profile. Solutions as for example implemented by the Open Source OSN service Friendica simply copy contents of a user profile to a new location, where identifiers are changed in the process, causing connections between OSN profiles to break. Therefore, OSN services need to specify a universal and implementation-agnostic technical solution that allows migration of entire user profiles while preserving connections between profiles stored at different locations. Such a migration protocol does not only need to copy a user account's data objects, but also needs to preserve privacy settings - such as access control policies [2] - as well as connections between user accounts.

3.4 Global User and Object Identification

The way how OSN services nowadays identify users and data objects, such as a user's profile page or a posted status update, differs between OSN services. Normally, OSN platforms issue locally unique identifiers for users, which can be resolved to the user's identity or data object only in conjunction with the issuing platform's domain name. While centralized OSN services do not require globally uniqueness of their user's identifiers, decentralized OSN services mostly utilize URLs or email addresses as identifiers for users and data [13]. As of this, the issuing platform always remains responsible for routing requests for user identities or data objects, even after migrating to a competitor's service. In case a user's social profile is moved to another OSN service and domain, a user's identifier would hence become invalid, causing connections between users in the social web to break. To prevent such situations, domain-agnostic identifiers for all user identities as well as all addressable data enclosed in the social profiles are required. Ecosystems that allow social profiles to remain independent from any OSN services domain by implementing domain-agnostic, yet globally unique identifiers for both users and all data objects would therefore provide a foundation for independent and portable social profiles. To allow identifiers to be resolved to a social profile's - or data object's - storage location, means to resolve identifiers need to be provided. To remain independent of any organization or company controlling the process, such a directory service needs to be distributed in itself, for example based on Distributed Hash Tables (DHT) [13] or Distributed Ledger Technology (DLT) [5]. Such a system would allow users to create and manage their own identities without any central entity being able to control or block the process.

4 TOWARDS AN OPEN AND HETEROGENEOUS SOCIAL WEB

In the attempt to supersede the leading OSN services, alternative proposals, such as Diaspora, Friendica, or Mastodon, have managed to attract only a comparably small number of users. Due to strong lock-in effects, users are reluctant of switching to alternative solutions, as one would lose all data and connections [35]. Moreover, as alternative solutions themselves implement mostly mutually incompatible protocols and communication standards [15], they stand no chance against the overly dominant market leaders as they cannot attract a significant amount of users.

To alleviate this situation of today's social web, we envision a common communication standard that would interconnect arbitrary OSN services in one large federation, in which loosely coupled OSN services allow their users to seamlessly connect to each other across platform borders. By implementing the required interfaces for communication and resolving identities [19], any existing or novel OSN service can connect to the OSNF. Users of participating services can not only freely choose their OSN service, but also seamlessly connect to any other user in the federation regardless of the OSN service platform they use. The envisioned solution addresses existing issues such as data privacy, lock-in effects, and missing interoperability and therefore allows users to connect to each other across platform borders and seamlessly communicate [19]. As stated by Palfrey and Gasser, interoperability of systems and services does not only provide a greater choice and autonomy for the consumer, but also supports competition and innovation, while additionally providing benefits for both customers as well as providers in terms of systemic efficiency [28]. Following this paradigm, current issues of centralized, proprietary OSN platforms, such as the lack of data privacy, lock-in effects or walled gardens, can be avoided altogether.

The four identified requirements as presented in Section 3 form the foundation of such a truly open and heterogeneous social web. As OSN services are able to connect to each other in a loosely coupled fashion using a common communication standard, users are able to connect to each other and access each other's social profiles regardless of the OSN service they use. Core functionality of the social web is supported by default, while extended functionality is provided via feature extension support. Furthermore, user profiles and associated data are identified via domain-agnostic identifiers and are therefore independent from the OSN service they were created in the first place. This allows user profiles and all associated data to be migrated between different OSN services without connections in the social web being severed in the process.

The project Sonic, as introduced in Section 1, proposes a distributed architecture and design for an open and decentralized OSNF. The OSNF is built on the idea of utilizing and combining existing OSN microstandards to provide a holistic framework for OSN interconnectivity. We envision an open, seamlessly interconnected, heterogeneous ecosystem of OSN platforms, in which users are not restricted to communicating with connected users of the same OSN platform, but can seamlessly interact and collaborate with users of other OSN services as platform borders become transparent. Lock-in effects, keeping users from abandoning an OSN service they are dissatisfied with, are eradicated as user profiles may be freely migrated from one OSN platform to another at any time without losing established relationships in the social graph. This would allow users to freely choose an OSN platform of their liking instead of being limited in their choice to the platform used by one's friends.

To realize this vision of an ecosystem of freely interconnected ONS services, we propose a holistic approach comprising an open and extensible social API as well as data formats. The APIs and data formats proposed are built around existing open standards to allow for a high compatibility with existing implementations while easing implementation and integration overhead for developers at the same time. This allows any OSN service provider to implement and integrate the required protocols and interfaces and connect existing OSN platforms to a global ecosystem of OSN services as envisioned by Yeung et al. in [37]. Furthermore, as more and more smaller OSN services connect themselves in the OSNF, a critical mass of users and services could be used to make the OSNF self-sustainable as described by Westland in [35]. This could cause a disruption of currently employed business models focused on centralization. Eradicating lock-in effects furthermore also allows users to freely communicate between different platforms and even migrate between OSN platforms at any time without losing any social profile data or connections to other users. Addressing the issue of social profiles being bound to the OSN platform they were created in by providing a holistic solution allows users to maintain social profiles at any server they want while allowing them to migrate profiles to a new server if wanted.

The project Sonic therefore introduces a solution for the effect of centralization as users of compliant OSN services are not locked-in anymore and the individual choice of a user for a specific OSN service does not automatically cut him off from communicating with other OSN services. As choosing a small OSN service instead of the one with the largest user base does not isolate users anymore, smaller or new OSN services stand a much better chance on the market. If OSN service providers cannot rely on network effects anymore, they need to compete for users via alternative benefits, such as better functionality, performance, support, or privacy. Consequently, Sonic re-introduces competition and innovation in the consolidated OSN market.

5 CONCLUSION

To address the prevalent situation of the social web being run by few organizations in a restrictive manner, alternative OSN architectures have been proposed that distribute control and data to multiple independent servers. Decentralization as an architectural concept promised users the ability to remain in control of any data they collected in their social profiles. Still, the implicit network effects that exist in large OSN services keep preventing users from migrating to alternative solutions in significant numbers, as abandoning one OSN service for another one would inevitably result in losing one's friend list, profile page, and accumulated data. In consequence, today's social web is dominated by few overly powerful OSN services, which were able to attract a significant amount of users while a large number of competing services and alternative solutions exist that combine a comparably rather small number of

users. The social web, which once was diverse and heterogeneous, has become a monoculture of few dominating OSN services.

Several challenges for an open and free social web have been listed and identified by researchers. While most researchers so far focused on data privacy [37][11][1] or technical questions [24][29][30], the lack of interoperability and data portability have been identified as the main challenges to be solved for a successful open and decentralized social web [16].

We argue that the social web should be interoperable and individual OSN services should be independent from any central entity or organization. Such a heterogeneous federation of OSN services would allow any large or small OSN to connect to the rest of the participating services, therefore becoming a part of it. The result of this would be an open and heterogeneous Online Social Network Federation (OSNF). In this paper, we present the four fundamental requirements for an architecture of the OSNF. Firstly, a core featureset of OSN functionality needs to be defined. Such a featureset would allow to build OSN services with the least common set of functionality. Second, a holistic interoperability protocol for federated communication between different OSN services is needed. The protocol needs to support extensibility in order to support extended functionality beyond the scope of the core featureset. To uniquely identify users and data objects across different OSN service implementations, a common identification framework is required. Identifiers need to be designed in a domain-agnostic fashion in order to prevent breaking links in case social profiles are moved between OSN services. Finally, an open and heterogeneous social web needs to support seamless data portability for entires social profiles including all associated data. Most importantly, established links between different OSN profiles must not break, but remain intact during the migration process.

Solving all four challenges would allow user profiles to become independent from the OSN service they were created in in the first place. This would weaken the overly powerful position of today's dominating OSN services and allow smaller OSN implementations to attract more users. After all, an open and heterogeneous OSNF would allow users to remain in full control of their own data and social profiles.

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