More Instant Messaging Interoperability (mimi)
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Interoperable Private Identity Discovery for E2EE Messaging
draft-party-mimi-user-private-discovery-03

Abstract

This document specifies how users can privately discover each other's Service Specific Identifiers (SSIs) when using end-to-end encrypted messaging services across multiple providers. Users can retrieve SSIs without revealing their social graphs to service providers they are not delivering messages through, using their phone numbers, email, user IDs, or other Service Independent Identifiers (SIIs). Our specification can be based on private information retrieval or associative private sets membership schemes, both of which provide reasonable tradeoffs between privacy and cost.

About This Document

This note is to be removed before publishing as an RFC.

The latest revision of this draft can be found at https://datatracker.ietf.org/doc/giles-interop-user-private-discovery/. Status information for this document may be found at https://datatracker.ietf.org/doc/draft-party-mimi-user-private-discovery/.

Discussion of this document takes place on the mimi Working Group mailing list (mailto:mimi@ietf.org), which is archived at https://mailarchive.ietf.org/arch/browse/mimi/. Subscribe at https://www.ietf.org/mailman/listinfo/mimi/.

Source for this draft and an issue tracker can be found at https://github.com/femigolu/giles-interop-user-private-discovery.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

This Internet-Draft will expire on 7 May 2024.

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1. Definitions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

A *service specific identifier* (SSI) is a unique identifier for a user within a single service provider's service, and encodes the service provider in the identifier. For example, a user's account handle and provider identifier is an SSI.

A *service independent identifier* (SII) is a unique identifier for a user that is independent of any specific service provider. For example, a user's E.164 phone number or email address are SIIs, since they can be used to identify the user across multiple different services.

2. Problem statement

The *discovery problem* is resolving a user's SII into one SSI for that user, while preserving user privacy in the process.

3. Threat actors

* Alice, Bob, and Carol: Three users within the interoperable E2EE messaging ecosystem.

* Sender Messaging Platform: A messaging service provider platform where a registered user has an account and has established a mapping of SII to SSI. Examples from Fig. is Platform 1 for Alice and Carol, and Platform 2 for Bob.

* Potential Recipient Messaging Platform: A messaging service provider platform where a discovered SSI is registered. An example from Fig. 1 is the role of Platform 2 when Alice resolves Bob's SSI using Bob's SII. This has three variants in the threat model:

    1. Recipient platform with SSI - the sender sends a message (so this platform will learn the sender identity).

    2. Non-recipient platform with SSI that the recipient SII has an account with but does not send a message to.

3. Non-recipient platform without SSI - potential recipient does not have an SSI registered with this platform.

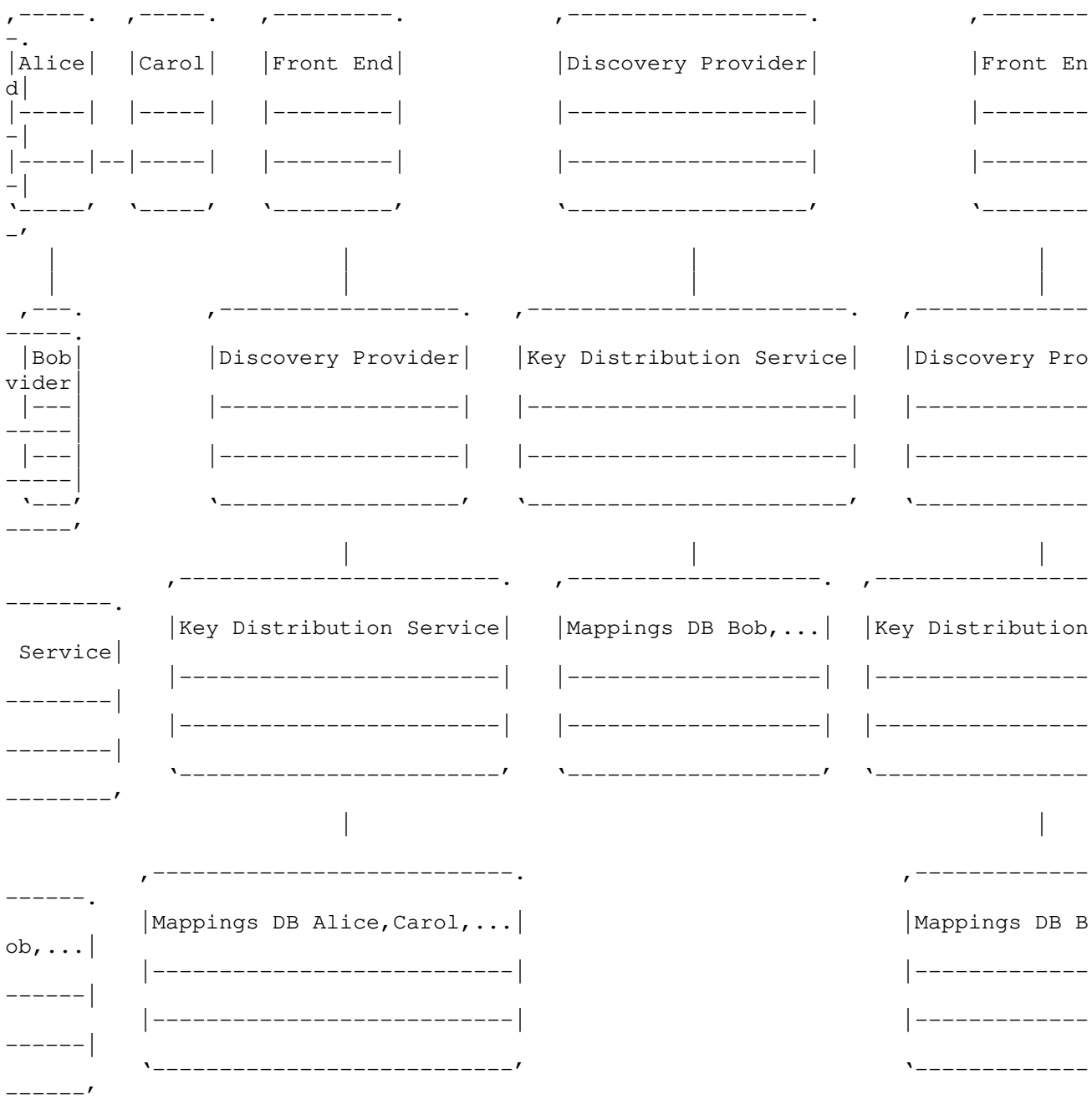


Figure 1: Threat actors and systems

* Third Party Platform: A platform that provides discovery services but is not a messaging service provider. Bob might register with such a service directly, or such a service may act as a proxy for Messaging Platform 2 through contractual business agreement.

* Front End: A service within a platform that receives users' requests and collaborates with other services to process them.

* Discovery Provider: Works to resolve SII to SSI.

* Key Distribution Service: Manages public key material of registered users.

4. Privacy requirements

1. *Social graph*: Discovery service providers should not learn the SII or SSI a user is querying for unless they are sending or receiving a message on to that user.

2. *Querying user identity*: A discovery service provider should not share the querying user identity with other discovery services when it requires their help for discovery.

3. *Metadata*: Discovery service should not learn the exact timing of when a message is sent (after discovery).

4.1. Requirements by threat actor

The following table describes the requirements to protect the privacy of an intended recipient's SSI during discovery broken down by the various threat actors. The possible list of services that may resolve a discovery request based on their knowledge of the SSI is shown in the first column. The second and third columns are the minimum and possible privacy requirements. The optimal privacy requirements assume that the two devices in E2EE messaging endpoints are on different messaging service platforms.

Note that current messaging systems segment a user's social graph across their contacts' messaging services. Without proper privacy mitigations, a discovery process for the new interoperable ecosystem can enable an attacker to aggregate these fragments of the user's social graph across different services, violating their privacy. Performing the discovery process for contacts that are never used is common so that it is very likely that most clients will perform discovery for SIIs that they never send a message to. This is why we propose hiding the SII from the sender platform unless a message is sent. We believe this is possible technically because:

1. Spam prevention requirements only apply to sent messages (standard IP based techniques can be used to prevent DDoS of the discovery service itself).

2. Client costs for SII hiding mechanisms scale well enough with database size + number of services.

Service	Minimum privacy requirements	Optimal privacy requirements
Sender Platform	Do not hide SSI	Hide SSI
Recipient Platform with SSI	Do not hide SSI	Do not hide SSI
Non-recipient Platform with SSI	Hide SSI	Hide SSI
Non-recipient Platform without SSI	Hide SSI	Hide SSI
Third party service	Hide SSI	Hide SSI

Table 1

Table 1: Discovery privacy requirements by threat actors

5. Privacy non-requirements

1. *Hiding SII <> service mapping*: Hiding service reachability or the existence of a mapping between an SII and SSI for a service provider is an explicit non-goal. All major E2EE messaging services already publish unACLd reachability information without opt-out i.e. +16501234567, reachable on Messages, Whatsapp, Telegram (not including name or any other info). Therefore this should not be a privacy goal (and would not be feasible to implement). *However it may be a business goal to prevent scraping of the full list of account-holders.*

2. *Contact lookup by name* or anything except an SII.

6. Other Non-functional Requirements

1. No single entity should be financially responsible for resolving all discovery queries (e.g. even within a geographical region).

2. Costs for each participating entity of storing and resolving SII should be proportional to their number of participating users.

3. Performance should support each client device resolving users' contact SIIs at least once every 24 hours.

7. SSI Discovery

SSI discovery means retrieving the SSI that an SII maps to. There are two alternative cryptographic techniques to achieve the privacy properties for the retrieval:

1. Private Information Retrieval (PIR)

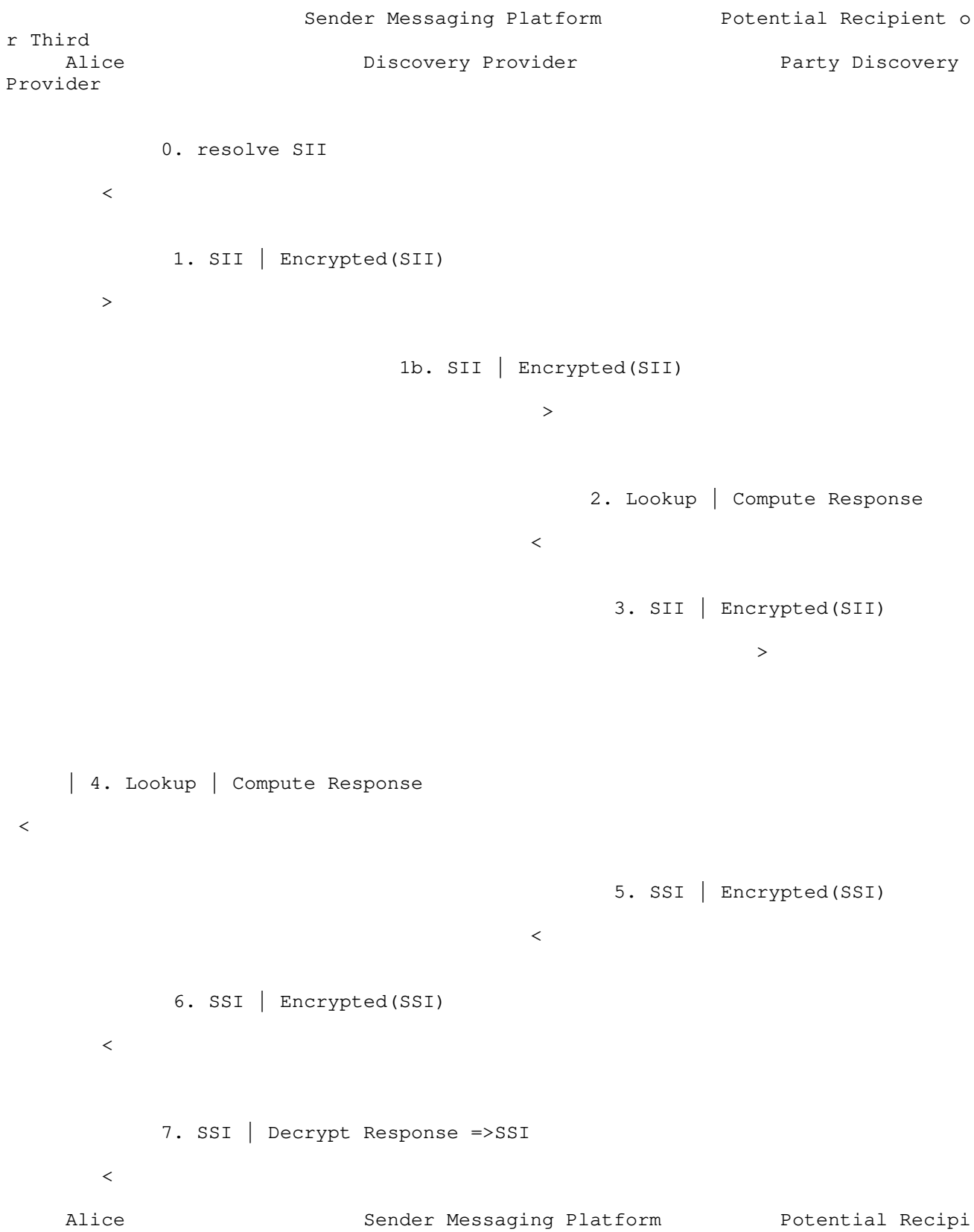
2. Private Set Membership (PSM)

The discovery process is illustrated in Figure 2. Optionally, Alices client may encrypt the SSI of interest using PIR or PSM before forwarding the SII query to the Discovery Provider of the Sender Messaging Platform.

The DP for the Sender Messaging Platform may either look up or compute an encrypted response directly, or it may forward the request to the Potential Recipient or Third Party Discovery Provider indicated by the provider identifier included in the request. Regardless of which party processes the request, a DP will compute an encrypted response and forward it back to Alice. Alice can then decrypt the encrypted response (if applicable) to obtain the SSI.

Alices client may also optionally send the discovery request directly to a potential recipient or 3p DPs.

We assume a fixed list of DPs for each SMP so that the client does not have to specify in the query request which DPs to use.


Sender Messaging Platform
Potential Recipient or Third Party
Alice
Discovery Provider
Discovery Provider
0. resolve SII
1. SII | Encrypted(SII)
1b. SII | Encrypted(SII)
2. Lookup | Compute Response
3. SII | Encrypted(SII)
4. Lookup | Compute Response
5. SSI | Encrypted(SSI)
6. SSI | Encrypted(SSI)
7. SSI | Decrypt Response =>SSI

Discovery Provider Party Discovery Provi
der

Figure 2: Discovery with Sender Messaging Platform

Note: * Note that the DPs should not learn that Alice is the author of the request. * Alice is not required to hide discovery requests when the processor DP is within the Sender Messaging Platform. * Alices client may, but is not required to hide discovery requests from Potential Recipient DPs. Both of these requests can be sent in the clear.

7.1. Private Information Retrieval (PIR)

A PIR protocol enables a client holding an index (or keyword) to retrieve the database record corresponding to that index from a remote server. PIR schemes have communication complexities sublinear in the database size and they provide access privacy for clients which precludes the server from being able to learn any information about either the query index or the record retrieved. A standard single-server PIR scheme provides clients with algorithms to generate a query and decode a response from the server. It also provides an algorithm for the server to compute a response.

We proposed a lattice-based PIR framework by Patel et al[PIRFramework] with sharded databases. This framework is applicable with any standard PIR scheme such as the open source implementation here (https://github.com/google/private-retrieval). Cost estimates suggest this is feasible even for a very large database with 10 billion records/mappings.

7.1.1. Cost estimates

Use database shards each of ~1 million mappings. For 1.28 TB (10 billion records), breaking this down into 10,000 shards each of size 1 million records gives a cost estimate for each query as below:

Parameter/Metric	Cost estimate
Server Storage Per Device	14 MB
Client Device Storage (for 10 billion records)	5 MB
Upload Bandwidth Per Query	14 KB
Download Bandwidth Per Query	21 KB
Client Time Per Query	0.1s
Server Time Per Query (Single Thread)	0.8-1s

Table 2

7.2. Private Set Membership (PSM)

The discovery provider holds a set of SIIs that maps to an associated set of SSI. A PSM protocol enables a client with an SII to lean the associated SSI held by the server with the following privacy guarantees:

1. The discovery provider does not learn the SII held by the client.

2. The discovery provider does not learn whether a matching SII was found or not.

3. The client does not learn any information about the other SIIs and associated SSIs held by the discovery provider.

An open source implementation is available here (https://github.com/google/private-membership).

7.2.1. Cost estimates

For a database with 1.28 TB (10 billion associated records of SSI), using 1,000 shards each of size 10 million records, the cost estimate for each query is:

Parameter/Metric	Cost estimate
Communication	2.8 MB
Client Time Per Query	0.1s
Server Time Per Query (Single Thread)	1-2s

Table 3

7.3. Cross-service identity spoofing

Today, a messaging service may support one or more ways of identifying a user including email address, phone number, or service specific user name.

Messaging interoperability introduces a new problem that traditionally has been resolvable at the service level: cross-service identity spoofing, where a user on a given E2EE may or may not be addressable at the same ID on another service due to a lack of global uniqueness constraints across providers.

As a result, a user may be registered at multiple services with the same handles, e.g. if Bob's email is bob@example.com (mailto:bob@example.com) and his phone number is 555-111-2222 and he is registered with Signal and iMessage, he would be addressable at bob@example.com (mailto:bob@example.com):iMessage, 555-111-2222:iMessage, and 555-111-2222:Signal. In this case, the same userId on iMessage and Signal is acceptable as the phone number can map to only one individual who proves their identity by validating ownership of the SIM card.

On services where a user can log in with a username _alone_, however e.g. Threema and FooService, the challenge becomes:

* Alice messages Bob at Bob's preferred service (bob@Threema)

* Eve messages Alice impersonating Bob using bob@FooService

* Alice needs some indicator or UI to know that bob@Threema isn't bob@FooSercice and that when bob@FooService messages, it should not be assumed that bob@FooService is bob@Threema.

Options for solving this are: 1. Storing the supported services for a contact in Contacts and if a recipient receives a message from an unknown sender, to treat it as spam or otherwise untrusted from the start. 2. Requiring the fully qualified username for services that rely on usernames only - e.g. bob@threema.com vs bob.

8. Thoughts on open questions from 10/10/2023 Interim Meeting[MIMI20231010]

8.1. Trusted Authorities for Mapping SIIs to SSIs

Which actors should be trusted authorities for mapping SIIs to SSIs?

In general, this should be considered out of scope for this proposal, however we expect that by default, Messaging Service Providers (MSP) should be trusted authorities for creating these mapping. Users may "own" their SIIs, but messaging service providers own SSIs. MSP should verify ownership of SIIs (one time password code to phone via text or call, or to email).

An MSP may share established mapping data with 3P discovery providers to facilitate lookups, or may delegate establishing new mappings to these providers under contractual agreements between them. Preferably, delegate discovery providers should be lookup providers only and should not create or update existing mappings unless the delegate is a reputable/trusted certification authority.

If a 3p discovery service is used, it may also authenticate the mapping independently or it may act as a pass-through for a signed mapping by an MSP or another identity provider.

SSL is sufficient to authenticate the mapping assertion.

8.2. Discovery Scaling

Does discovery need to scale to accommodate 10s, 100s, or 1000s of service?

A discovery request should be sent to a specific MSP or 3P discovery provider. It is up to those providers if they want to fan out the discovery to other providers or answer the discovery request from its own mapping only. It will be costly to fork out discovery requests to a large number of discovery providers while completely hiding the SSI from these providers. We do not want forking to fit DDoS patterns on these services.

However the protocols should be feasible (in terms of computation and communication cost) for 1000s of services.

8.3. Acceptable leakage for discovery

What is it acceptable for queries to reveal about the social graph, and to whom?

A query should not reveal the SII in a user’s query to discovery providers unless the discovery provider is also within the Sender’s platform or the Recipient’s platform with the SSI mapping. For an encrypted query and *since discovery precedes E2EE messaging*, a discovery provider won’t be able to tell if the SSI maps to an SSI in its service. It is okay to take the no-leakage approach for all providers.

Alice may use the different provider owning each SSI that her phone maps to. Bob may use different email addresses to map to multiple SSI with the same provider.

Returning an SSI set of different cardinalities leaks information to a discovery provider about the likely sets of SSIs that are of interest for a query. A one-to-one mapping of SII to SSI does not leak such information. A discovery provider cannot tell when a privacy-preserving discovery returns an empty result or a single SII. However, it will be able to tell when a large number of SSIs are returned.

8.4. Rate Limiting

Is rate limiting useful to prevent scraping?

It is up to a discovery provider to rate-limit given the potential computational cost of responding to batch queries from a single user. Nonetheless, we should require that a user should be able to look up no less than 50 SII per discovery provider for each messaging provider in a given 24 hours period. Third party discovery providers are under obligation to messaging service providers and are excluded from the minimum discovery load per user.

8.5. SII Mappings

An SII may map to multiple SSIs. Should the requestor learn all of them, and if so, how?

* _One service that returns all SSIs for an SII?_

* _Query each service provider independently?_

* _User figures out out-of-band what service provider to query?_

SII mapping to multiple SSIs within a single provider

1. This is a choice that MSPs will have to make, if they want to allow it.

2. Having multiple SSIs per SII makes preserving the privacy of discovery more challenging because of the side channel leakage of response size. The tradeoff is acceptable if on the average users have multiple SSI with a MSP.

3. For privacy reasons (i.e., protecting the association of multiple SSIs), the user may not want to group multiple SSIs together.

4. We may devise a scheme where an SII could be suffixed with an index during registration and discovery of the SSI to retrieve from the set. For example, given an SII +1234567890, a user may map +12345678900 to the first Whatsapp SSI, and +1234567891 to the second Whatsapp SSI and so on.

The user should figure out out-of-band what discovery provider to query, and discovery providers should not be required to fork out discovery requests to other providers given the computational cost impact.

8.6. Notes

9. IANA Considerations

This document has no IANA actions.

9.1. Appendix

10. Normative References

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[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/rfc/rfc8174>.

Acknowledgments

The technical description of the private information retrieval framework is based on Sarvar Patel, Joon Young Seo and Kevin Yeo’s USENIX Security ’23 paper titled "Don’t be Dense: Efficient Keyword PIR for Sparse Databases " (https://www.usenix.org/conference/usenixsecurity23/presentation/patel).

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MIMI Discovery Requirements and Considerations
draft-rosenberg-mimi-discovery-reqs-01

Abstract

This document defines requirements and use cases for the discovery problem in the More Instant Messaging Interoperability (MIMI) working group. The discovery problem refers to the process by which a message sender can identify the provider(s) associated with a desired messaging recipient, who is normally identified by an email address or phone number.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

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This Internet-Draft will expire on 5 September 2024.

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1. Introduction

The More Instant Messaging Interoperability (MIMI) working group is chartered to enable federated messaging, voice, and video service between application providers, such as WhatsApp, Facebook Messenger, and other vendors. The MIMI protocols cover the exchange of encrypted content [I-D.ietf-mimi-content] through transfer protocols [I-D.ralston-mimi-linearized-matrix]. These protocols allow a user in one provider to initiate 1-1 and group messaging with a user in a second provider. The protocol requires that the originator of the

communication know two things about the target user - their messaging provider, and a unique identifier for that user within that provider. The specifications recognize that the originator will not always know the provider for the target user, or the service-specific identifier for that user on that provider. The problem is further complicated by the fact that a users often make use of multiple messaging applications, in which case the preferences of the target user need to be taken into account as well. These preferences are even less likely to be known by the originator of communications.

Rather, in many cases one user will have an email address or phone number for the target user, obtained from their address book on their mobile device. Neither the phone number or email address identify the messaging provider that the target user is using. Unlike email service, the domain portion of a user's email address has no bearing on what messaging provider they use. A user joe@gmail.com might be using WhatsApp or iMessage, neither of which are Gmail. Thus - the core problem is - how to take one of these service independent identifiers and learn the messaging service that user is using, and how to send messages to them on that messaging service.

The MIMI framework hypothesizes the existence of a discovery or directory service to solve this problem. The discovery service would allow the originator to take a servide independent identifier for a target - such as a mobile phone number or email address - and perform a lookup to determine the preferred service(s) of the target user, along with enough information to reach them on that service.

This document describes requirements and use cases for solutions to the discovery problem.

2. Definitions

* Service Independent Identifier (SII): A type of identifier for a user that is unique (such that an SII is associated to only a single user), and independent of any specific communications service. There are two specific identifiers in this case - a phone number (landline or mobile), or an email address.

* Service Specific Identifier (SSI): A type of identifier for a user that is unique (such that an SSI is associated to only a single user), and achieves its uniqueness by being composed of two parts - a user part, scoped to a provider of communication services, and a unique identifier for the communication service provider. In some services, the user part is not globally unique across services. Examples of this case are Wire, Twitter and Skype, where user handles are flat - @jdrosen2 on Twitter, for example. In other services, the user part is globally unique, and

corresponds to the email address or mobile phone number (SII) for the recipient. Examples of this case are WhatsApp, iMessage, and Facetime.

* Personally Identifying Information (PII): Information about a target user that is not unique, but can be used to facilitate a search for the target user. Typically this would be the first name and/or last name of the recipient. The search would provide a list of possible matches, along with additional information, such as display names and avatars, which help the initiator find the specific person to which communications is desired.

* Application Provider (AP): A provider of messaging, voice, video and communications services to end users. An application provider is the entity that would implement the MIMI protocols. Examples of application providers are WhatsApp, Facebook Messenger, iMessage, Wire, Matrix, and so on.

* Discovery Provider (DP): A provider of discovery services, capable of mapping an SII to an SSI. This entity does not yet exist, and this document defines requirements for the protocols and processes behind it.

* Telephone Number Service Provider (TNSP): An entity which has authoritative ownership of the phone number used by a user. In the case of a mobile phone number, this would be their mobile operator (e.g., Verizon or AT&T in the United States). For a landline number, in would be their landline voice provider, which can include incumbent landline providers, but may also include non-traditional providers of voice and SMS services, like CPaaS (Communications Platform as a Service), such as Twilio or Nexmo, CCaaS (Contact Center as a Service), such as Five9 and NICE/InContact, and UCaaS (Unified Communications as a Service) providers, such as RingCentral, Webex and Zoom. We use Number Provider (TNSP) and not "operator" to keep this general purpose and to emphasize the fact that the key consideration for the discovery service is the assignment of the number to the user, not the provision of communications services against that number.

* Email Provider (EP): An entity which has authoritative ownership of the domain name portion of the email address used by a user. This would be Google for gmail.com, or Verion/AOL for aol.com as two examples. The EP for an email address can also be an enterprise, such as Cisco for cisco.com email addresses. As with telephone numbers, the EP is simply the provider of the address, and may not also be the provider of all communications services against that address.

* Cloud Provider (CP): An entity providing services to enterprises for voice, video and messaging services, acting as the Application Provider for employees of its enterprise customers. The CP is the TNSP for some numbers used by the enterprise, but not always.

3. Prior Efforts

Discovery services are far from new on the Internet.

The whois protocol, originally specified in [RFC0954] and later revised by [RFC3912], was largely focused on the mapping of domain names, to services associated with those domain names, and was one of the first discovery services deployed on the Internet. The DNS SRV record was specified in [RFC2782] and allows a similar discovery process - given a domain name, allows a querier to learn the set of services, such as VOIP based on the Session Initiation Protocol (SIP) [RFC3261] [RFC3263]. The SRV record was adapted to messaging in particular [RFC3861]. Whois and DNS SRV records both assumed that the lookup was keyed by a domain name, and thus they were not that useful for looking up an identifier that is not domain scoped, such as a mobile phone number.

This was first addressed through the specification of ENUM [RFC3761] in 2004. ENUM defined the usage of DNS to lookup phone numbers, by convering a phone number to a DNS name by reversing the digits and adding the suffix "e164.arpa". This allowed portions of the namespace to be delegated to telco providers that owned the number prefix in question. Though technically simple to define, its public deployment was hampered by the challenges of establishing authority for the prefixes. Private ENUM [RFC6116] services however have become relatively common, facilitating routing for many functions, including MMS routing in the messaging space.

Another attempt was made with ViPR (Verification Involving PSTN Reahability) [I-D.rosenberg-dispatch-vipr-overview] [I-D.petithuguenin-vipr-pvp]. VIPR made used of a peer-to-peer network based on RELOAD (Resource Location and Discovery) [RFC6940], running between enterprises. It solved the problem of authority problem by authorizing records based on proof of forward routability. However, it had the same network effects problem as ENUM. It also addressed the incentive problem, by focusing on enterprises for which bypassing the phone network would provide cost savings. However, the network effects problem proved insurmountable (amongst other challenges unrelated to the protocol), and it was never widely deployed.

Discovery and lookup services are now common place on the Internet but are scoped entirely within large providers, such as Facebook, Twitter, WhatsApp and other providers.

The MIMI discovery service requires a solution that spans across providers.

4. Reference Architecture

The reference architecture is shown below.

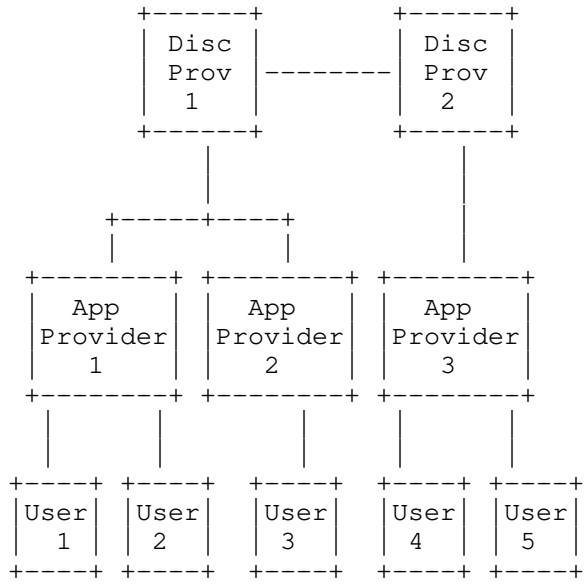

Figure 1: Discovery Architecture

There are many users in the system, with each user making use of zero or more communication applications, each provided by an Application Protocol (AP). Those application providers, in turn, connect to a Discovery Provider (DP) which is capable of mapping the SII to an SSI. In some cases, APs may themselves act as DPs. As shown in the diagram, one of the requirements is that there can be more than one DP, in which case there will be a need for some kind of inter-DP communication or federation.

5. App Provider Variations

There are many variations on who the app provider is, and what their relationship is with the user of the messaging service and the number and email providers for the identities. We can invision the following variants, all of which should be supported by both MIMI and the discovery service.

The variations are discussed below in order of decreasing commonality. For each one, we also discuss their cardinality (how many of them there are), how large of a population of users they serve, and how likely they are to participate in MIMI and the discovery service.

5.1. Consumer OTT

In this case, the App Provider offers services to consumers. The consumer has an email address and/or phone number, but the EP and TNSP for those identifiers have no relationship whatsoever with the AP. Examples include Apple's iMessage, Facebook Messenger, Wire and so on. However it does not include Google Messaging (RCS) which is the next category.

A very small number of these providers dominate messaging today. Many, but not all, are gatekeepers. Most are extremely large, supporting millions or more consumers. It is reasonable to expect the smaller, non-gatekeeper ones, to directly request interop with the gatekeepers as it is core to their business.

The smaller consumer OTT providers will be highly incented to participate in MIMI. They may, or may not, be incented to participate in the discovery service. Some of them do not make use of SII's in their services. For those providers, they would require that their users be reached because users in other APs know the SSI instead. Similarly, for their own users to communicate with other consumer OTT providers, they may require their users to know their SSIs.

If we were to only consider the consumer OTTs, we might conclude that SII to SSI mapping (discovery) is not needed - users can just use a drop-down menu of providers when reaching out to another user (this is sometimes called a nascar menu). However, it becomes untenable when you consider the additional use cases below.

5.2. Consumer Operator Aligned

In this case, the app provider offering services to its consumers is affiliated to the Telephone Number Service Provider (TNSP) for its users, and therefore has authoritative knowledge of the ownership of phone numbers for its users. The primary use case here is Google Messaging, provided through the Rich Communications Service (RCS) providers, which are the mobile operators, or Google who can operate it on their behalf. It may also include residential triple-play providers (MSOs and so on) that enable messaging for landline numbers.

There are many operators globally, numbering in the hundreds. Today, the only ones offering consumer messaging are the mobile operators.

5.3. Enterprise Cloud

In this case, another entity - the Cloud Provider (CP) is involved - which is a CCaaS, UCaaS or CPaaS provider offering communications services. The enterprise contracts with the Cloud Provider, which acts as the Application Provider (AP). The Cloud Provider is often also the Number Provider for the enterprise numbers used by enterprise employees. However, the Cloud Provider will often instead themselves contract with TNSPs to obtain numbers for its enterprise customers, which can then route to it over private SIP trunks for voice, and usually some non-SIP APIs for messaging. Examples of enterprise cloud APs are Five9, Cisco Webex, RingCentral, Microsoft Teams, Zoom, and so on.

The enterprise use case brings an additional consideration as well - in that many numbers (and email addresses) represent a service rather than a user. THink of the 1-800 number for a business, or an email address for customer support, or a phone number for an enterprise helpdesk. These are all services, behind which one or more users may reside.

There are a relatively small number of larger enterprise cloud players, perhaps numbering the few dozen. They tend to each have a smaller number of users than the consumer OTT providers (typically in the hundreds of thousands to millions of users). They also have economic incentive to request interop with the gatekeepers, since it reduces their direct costs for routing messages, voice and video calls. It would also likely increase the appeal of their products, which could offer consumer interconnection as part of their offerings, along with b2b federation between cloud providers.

For enterprise clouds to participate in MIMI, the discovery solution is much more important. This is because these companies are often not brands that are not consumer recognizable, there are too many of them to fit in a selector UI, and it is often impossible for a sender of a message to figure out what provider the recipient is on. This is especially problematic for the case where the SII represents a service and not a user.

5.4. Enterprise On-Prem

In this case, the app provider offering messaging services is an enterprise, who is doing so through on-premise messaging software they deploy and operate. The enterprise will always be the Email Provider (EP), but they are not the Telephone Number Service Provider (TNSP). That said, the enterprise connects to the TNSP via SIP trunks to enable calls to/from those numbers to reach it. One can think of this as the case where the enterprise is its own cloud provider. These cases are less common these days, but still exist. Examples are any enterprises running Cisco Jabber on-prem or Microsoft OCS or LCS on prem.

There are of course a large number of enterprises in the world which have historically had some kind of on-prem software, numbering in perhaps the hundreds of thousands. The ones which still do so is much smaller, but still a much larger number than the number of enterprise cloud providers. These enterprises are less likely to request interop with gatekeepers, just because they each serve a much smaller number of users and their incentives for doing so are less.

For enterprise on-prem use cases, the discovery service is absolutely required for their users to be reached for inbound communications. There is simply no way that other users will be able to select from a dropdown list of company names.

5.5. Consumer On-Prem

In this last case, the app provider offering messaging services is the consumer themselves, who is running some software in their home network or in a public cloud compute environment, which they deploy and operate. The consumer is neither a TNSP or an EP. This is a relatively uncommon case these days. It was not uncommon for people to run their own mail services for their home, but since messaging has predominantly been cloud based it is not as common there. That said, it is certainly possible for a consumer to run (for example) their own Matrix server in their home for their family.

It is extremely unlikely a consumer on-prem user would ever request interop with a gatekeeper. And, discovery is absolutely needed for the user to be reached for inbound communications.

6. Core Requirements

There are four key requirements:

1. Mapping: The service must provide a way to map from a SII to one or more application providers, and where necessary, to SSIs valid for those applications.

2. Validity: The mappings provided by the service must represent the wishes of the user associated with the SII, mapping to an application they are a user of, and the mapped SSI must be the one associated with this user. The core issue is one of trust, and how to determine that the mappings provided by the service are accurate.

3. Critical Mass: The network effects problem is perhaps the hardest to solve. But, to be viable, any solution must be able to reach a critical mass of mappings so that it becomes useful to consume, and thus useful to further populate.

4. Incentive Alignment: There must be an incentive structure which motivates the population of mappings into the service, and for the consumption of those mappings.

7. Identifier Types

1. Mobile SIIs: SIIs must include mobile phone numbers.

2. Landline SIIs: SIIs must include landline phone numbers.

3. Email addresses: SIIs must include email addresses

8. Provider Cardinalities

1. Zero APs: The system should work when a user - and their SIIs - are not associated with any discoverable APs. In this case, the discovery operation should indicate a no-match. This would enable an originating user to learn that they cannot reach that SII (short of sending an email or SMS, say).

2. One AP: The system should work in the simple case when a user as a single AP.

3. Multiple APs with Default: The system should enable a user to have multiple APs. The discovery service should enable user preference to be considered, so that a user can choose a default AP to use.

4. Business vs. Consumer AP: It should also be possible for a user to indicate that different APs are used for business purposes vs. consumer purposes. As an example of this case, user Alice might use WhatsApp for friends and family, but use Microsoft Teams at work. Her mobile number is used as an SII in both providers. When a user Bob on Webex Teams searches for that number, Bob would only get the Microsoft Teams SSI because their Webex Teams administrator has specified that messaging is between business APs by default. In another use case, Bob would get both of these back and would have the ability to choose whether to use the business or personal AP.

5. Circle Based APs: It should be possible for a user to specify that different APs are to be used for different contacts. For example, user Alice might use WhatsApp when talking to friends, but use iMessage when talking to family. When Bob, Alice's friend enters her number into his messaging app, the result depends on whether Alice has specified that he is a friend vs. family member [NOTE: I think this is probably more than we need and it adds a lot of complexity. I include it here for completeness to explore how deep this rabbit hole goes].

9. Caching

Given the significant volume of inquiries which might be sent, caching is a useful feature of the discovery service.

1. Cacheability of Results: The discovery service should allow for mappings to be cached by the AP. The DP must be able to tell the AP the duration over which the mapping can be cached.

2. Cache Invalidation: To handle changes in preferences or SII releases, it must be possible for the DP to inform the AP when a mapping is no longer valid ahead of its cache expiration.

10. Number Portability

When the SII is a phone number, porting comes into consideration.

The requirements depend on whether the user's operator - basically their number provider (TNSP) - is also the Application Provider (AP). When these are intertwined, porting a number also changes providers. Consequently, we can break this down into four distinct use cases and requirements.

1. Donating Operator is not the AP, and neither is the recipient. The number port should change nothing, the discovery service should continue to resolve to the AP.

2. Donating Operator is not the AP, but the recipient operator is an AP. The user now effectively has two APs - the OTT one before the port, and now a second one because their new operator is an AP, in essence enrolling them in the service by virtue of being an AP. In this case, it should be possible for a user to express a preference about where to receive incoming messages.

3. Donating Operator is the AP, but the recipient operator is not an AP. In this case, by porting away from their prior operator who was also an AP, the user has terminating their relationship with the messaging provider, and now has no provider at all, since their new operator is not also an AP. As it relates to the discovery service, once the port is complete, the user should be shown as no longer discoverable, and their prior mapping is deleted.

4. Both Operators are APs: In this case, the user has basically moved providers from one to another. As it relates to the discovery service, once the port is complete, the discovery service should indicate that their SSI is now on the new operator/AP.

11. SII Release

If a user is associated with a phone number by virtue of being a customer of a TNSP that is providing them that number, their association with that number will end once the user terminates their relationship with their TNSP. It is typical in telephony systems for that number to go into a waiting pool for several months before it can be reassigned to a different user.

For email addresses, it is also possible for a user to lose their association with an email address when they end service with that provider. Although reclamation of email addresses is possible, it is less common. Nontheless, it is technically possible.

This release process adds requirements for the discovery service.

1. SII Release Timeliness: If a user terminates service with a TNSP or EP, and thus loses their association with a number or email address from that provider, any mappings in the discovery service keyed by that SII should be removed within a month. Note that, this is an extremely difficult requirement to meet. It is certainly not met today by most messaging systems internally that use numbers as identifiers. For any OTT AP, the only way this requirement can be met is periodically reverifying ownership of the number through an SMS or phone call. This is burdensome to the user, and consequently, generally not done. Meeting this requirement without disruptive re-verifications requires the discovery providers (DPs) to have feeds into global number databases. For email addresses, this is even more untenable.

12. SII Claim

When a user starts their association to a number or email address, we can think of this as a "claim". Their claim is rooted in the start of services from the Number Provider (TNSP), Cloud Provider (CP) or Email Provider (EP) towards the user. This introduces a timeliness requirement.

1. SII Claim Timelines: Once a user is associated with an SII by virtue of obtaining service from a TNSP, EP, or CP that owns the given SII, it must be possible for the user to utilize that number with an AP and become discoverable immediately upon provision of service. This reflects a real, common use case. A user gets a new mobile phone with a new mobile phone number, and before even leaving the store, installs WhasApp or uses Google Messaging on their Android (which is RCS based) and expects it to work. Furthermore, they will contact their friends and family right away, giving them the new number, and expect to be reachable. The same applies to email addresses, though those change less frequently in the consumer space. In the enterprise space however, email addresses are frequently assigned and similarly, we want the user to be immediately discoverable.

2. When a user associates their SII with an Application Provider, there must be some way for the app to validate that the user controls the SII. Moreover, the app must have some way to prove that this validation was performed to third parties, such as other app providers, in order to prevent blackholes and similar attacks.

13. Organizational Requirements

A key consideration is - who runs, or can run, the discovery service?

1. Multiple Providers are Possible: One can imagine a design for the discovery service in which there is a single, worldwide global provider of the discovery service. This would certainly simplify the protocol and its security properties. There are some precedents for a singleton provider of service in the Internet – see ICANN and IANA. However, neither of these run operational services. Even the Internet's primary global service – the DNS – is in practice distributed amongst many different entities that run and operate the top level domain name servers. As a result, the discovery service should follow a similar pattern and allow for multiple providers of the discovery service.

2. Organizational Principles deliver trust: Once we accept that there can be many such providers of discovery services, how would an application provider (AP) know whether to trust the mappings that it provides? One answer is – this is just left to the market to decide, and the IETF has nothing to say on the matter. The alternative is that – the IETF defines the solution in such a way that there are ways for trust to be established. As one such example, the solution could be specified such that the solution for phone numbers makes use of existing number ownership structures that support STIR/SHAKEN [RFC8224] [RFC8225]. Or, it could define the solution in such a way that entities which already hold this routing information for messaging apps (i.e. using the Pathfinder service from Neustar which provides this mapping today for the GSMA) expose APIs for it.

3. PII Residency within Geopolitical Boundaries: There are increasingly regulations being passed, like GDPR, which require that personal data remain within certain geopolitical boundaries. Since the discovery service may contain such information, it must be possible for the DPs to sit within a geopolitical boundary and hold data for users within those geopolitical boundaries.

4. Invisible to Consumers: There are a class of solutions wherein a DP is directly visible to consumers, who would sign up, verify their number with it, and configure their preferences with it. However, this is unlikely to work in practice. It suffers from a significant network effects problem, such that signing up for the service would provide no value to its users until critical mass is reached. This would disincent users from signing up in the first place. As a result, the only solutions which can really work are those which are invisible to users, where the App Provides themselves send request to – or act as – DPs. That does however raise the question of how user preferences are expressed in the system.

5. Numerous App Providers: This is as much a requirement in MIMI, as it is for the discovery protocol. But, the goal is that we want a system wherein there can be a lot of app providers, many of which are smaller in size. This becomes even more obvious when we consider enterprise use cases, where a business might be its own provider for its own employees, and want them to be able to message consumers as well as other businesses using business numbers or business email addresses. In such a scenario, the number of APs can be in the thousands or more.

6. DP Federation: Because there are multiple DPs, run by different entities, it must be possible for some kind of federation so that an AP can request a mapping from one DP, and the mapping can be provided even if it resides within a different DP. Note that - this requirement could be contested. There is an alternative world view, wherein each AP needs to connect to every DP, with each DP holding a subset of the mapings. The drawback of such a system is, if we think DPs are aligned against geopolitical or organizational boundaries, it may be impossible or impractical for such a full-mesh configuration.

7. DP Federation Policy: Due to geopolitical considerations, it must be possible for a DP to decide to federate, or not federate, with other DPs. Such policies are outside the scope of this work, but this fact may result in some SIIs not being discoverable in certain geographical or political regions.

14. Blackhole Prevention

If we accept the requirement above that there can be a large number of app providers, including enterprises themselves, there is a large risk that one of them is malicious. The main attack we wish to prevent, is for an AP to claim it has a user associated with a given SII, when it in fact does not. Though MLS would (to the degree e2e identity works against that SII) prevent the recipient from reading messages sent to that SII, it is certainly possible that they can "blackhole" them. This is an attack wherein the malicious AP causes the SII to map to its own SSI, rather than the legitimate SSI for the user. This would deny receipt of messages at the legimiate SSI, and thus is a form of denial of service.

The concern over blackhole attacks introduces several key requirements.

1. Malicious AP cannot blackhole against a legitimate AP: A critical security requirement for the discovery service, is that is not possible for a malicious AP to create a blackhole.

2. Malciious AP cannot make a user appear discoverable even though they are not: In this case, a user Bob is not a user of any AP. In a functioning system, they would show as not-discoverable to users searching for them based on their SII. In this attack, a malicious AP tries to convince the discovery service that they are in fact a user of the malicious AP. Even though the malicious AP cannot decrypt the incoming messages, they will cause other users to now view user Bob as discoverable. This is a less severe version of the above attack, but is still an attack. It would potentially fool senders into thinking they have reached a target that is ignoring them, which can cause unintended consequences.

3. Ultimately, the DP must have a direct assurance that a particular SII has been authentically associated with an Application Service before allowing that app to be discovered as a mapping for the SII.

15. Spam Prevention

Spam is a significant concern in the system, and its risk grows exponentially with the number of APs connected to the system. As noted above, many use cases have a large number of APs, which can pose a serious risk. Spam prevention needs to be considered at both the MIMI layer (using techniques like connection requests and reputation safeguards), but can also be addressed at the discovery service.

Note that SIIs act as "front doors" for end users today, and there is an inherent risk in having one - especially telephone numbers, as the numbering space can be relatively easily enumerated. Making an SII discoverable necessarily opens the door to receiving unwanted or unsolicited communications, much of the mitigation of which will be the responsibility of apps and of user applications.

1. No Enumeration: The system must protect against an enumeration attack. An enumeration attack is one wherein a malicious AP attempts to look up a large number of SIIs - especially phone numbers which can easily be enumerated as they are finite - in order to learn the SSI assocaited with each. Once an SSI is known, the malicious AP has an address it can add to its spam list. Today, many people avoid listing their email addresses or phone numbers on public websites to prevent spam sites from scraping those identifiers to add them to target lists. We don’t want the discovery service to be a nice, convenient and easily farmable source of identifiers for sending spam.

2. Rate Limits: The system must provide rate limit capabilities to restrict an AP from sending too many discovery requests. There must be a way for the Discovery Provider (DP) to assess what a reasonable rate limit might be for that AP.

16. DP Social Graph Privacy

The Discovery Provider (DP) will receive requests from APs to map a given SII to a provider and/or SSI. These requests themselves create a form of social graph, indicating what SIIs are often requested, and which are not. This leaks information to the DP. The following requirement tries to limit exposure of the DP to this information.

1. DP Unaware of Requested Number: A DP must protect at least one end of the social graph during a request: the DP must be kept ignorant of either the querier's identity (including IP address) or the SII of interest in requests. For exampple, IP blinding could conceal the querier's identity, or techniques such as Private Information Retrieval (PIR) could conceal the SII from the DP.

2. DP Minimal Federation: The federation techniques should avoid propagating mappings from one DP to another DP unless there is a legitimate need for that DP to know of a mapping - for example in order to satisfy a query. While the business relationships that may underlie DP federation are outside the scope of these requirements, federations may institute their own policies to protect consumers and private business data.

3. DP User hiding: A DP should not share the querying user identity with other DPs when it requires their help for discovery.

17. Encryption

At the risk of stating the obvious, but:

1. Encrypted Transport: Exchange of information between DPs, or between DPs and APs, should always be encrypted in transit.

18. AuthN

Also obvious, but:

1. Authentication: It must be possible for two DPs federating to identify each other, and it must be possible for a DP and AP communicating with each other, to identify the other party.

19. Hard Problems

From these requirements, a few areas have emerged that warrant particular attention in potential solutions:

1. Multiple mapppings. If there are multiple candidate app mapppings discovered for a given SII, what do we expect the behavior will be at a protocol level? Will a message be sent to each app? Will a nascar menu be presented to the user? Or will just one be selected through some sort of preferences mechanism? In the last case, especially when apps themselves act as DPs, is it legitimate for apps to prefer to route an SII to its own service rather than to competitors?

2. Preferences and capability negotiation. If there are multiple potential mappings for an SII, how much should the preferences of the sender and recipient of communications be weighed, and how should those preferences be expressed? Because users may tacitly or explicitly establish contexts for their messaging contacts (business on one app, personal on another, say), how rich would the expression of such preferences need to be?

3. Authentication and expiration of mappings. How rigorous does the process need to be for validating mappings in order to prevent blackholes and similar threats? How do the mappings created for discovery relate to the identities asserted at the protocol level, e.g. [I-D.mahy-mimi-identity]? Once an SII has been claimed by a user and enrolled at one or more messaging apps, how long should that mapping persist before expiring, as some SIIs change ownership over time?

4. Protecting user privacy. How much information can we shield from the DP, or indeed the appp itself, while still enabling a messaging system? How do we prevent enumeration attacks if we want these mappings to be basically publicly available? How do we balance user privacy with spam protection? What is the threat landscape for pervasive monitoring of social graphs associated with messaging?

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