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Modern Problem Statement, Use Cases, and Framework
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Abstract

The functions of the public switched telephone network (PSTN) are rapidly migrating to the Internet. This is generating new requirements for many traditional elements of the PSTN, including telephone numbers (TNs). TNs no longer serve simply as telephone routing addresses: they are now identifiers which may be used by Internet-based services for a variety of purposes including session establishment, identity verification, and service enablement. This problem statement examines how the existing tools for allocating and managing telephone numbers do not align with the use cases of the Internet environment, and proposes a framework for Internet-based services relying on TNs.

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1. Problem Statement

The challenges of utilizing telephone numbers (TNs) on the Internet have been known for some time. Internet telephony provided the first use case for routing telephone numbers on the Internet in a manner similar to how calls are routed in the public switched telephone network (PSTN). As the Internet had no service for discovering the endpoints associated with telephone numbers, ENUM [3] created a DNS-based mechanism for resolving TNs in an IP environment, by defining procedures for translating TNs into URIs for use by protocols such as SIP [2]. The resulting database was designed to function in a manner similar to the systems that route calls in the PSTN. Originally, it was envisioned that ENUM would be deployed as a global hierarchical service, though in practice, it has only been deployed piecemeal by various parties. Most notably, ENUM is used as an internal network function, and is rarely used between service provider networks. The original ENUM concept of a single root, e164.arpa, proved to be politically and practically challenging, and less centralized models have thus flourished. Subsequently, the DRINKS [4] framework showed ways that service providers might provision information about TNs at an ENUM service or similar Internet-based directory. These technologies have also generally tried to preserve the features and architecture familiar to the PSTN numbering environment.

Over time, Internet telephony has encompassed functions that differ substantially from traditional PSTN routing and management, especially as non-traditional providers have begun to utilize numbering resources. An increasing number of enterprises, over-the-top voice-over-IP (VoIP) providers, text messaging services, and related non-carrier services have become heavy users of telephone numbers. An enterprise, for example, can deploy an IP PBX that receives a block of telephone numbers from a carrier and then in turn distribute those numbers to new IP telephones when they associate with the PBX. Internet services offer users portals where they can allocate new telephone numbers on the fly, assign multiple "alias" telephone numbers to a single line service, implement various mobility or find-me-follow-me applications, and so on. Peer-to-peer telephone networks have encouraged experiments with distributed databases for telephone number routing and even allocation.

This dynamic control over telephone numbers has few precedents in the traditional PSTN outside of number portability. Number portability allows the capability of a user to choose and change their service provider while retaining their TN; it has been implemented in many countries; either for all telephony services or for subsets such as mobile. However, TN administration processes rooted in PSTN technology and policies dictate that this be an exception process fraught with problems and delays. Originally, processes were built

to associate a specific TN to a specific service provider and never change it. With number portability, the industry had to build new infrastructure, new administrative functions and processes to change the association of the TN from one service provider to another. Thanks to the increasing sophistication of consumer mobile devices as Internet endpoints as well as telephones, users now associate TNs with many Internet applications other than telephony. This has generated new interest in models similar to those in place for administering freephone services in the United States, where a user purchases a number through a sort of number registrar and controls its administration (such as routing) on their own, typically using Internet services to directly make changes to the service associated with telephone numbers.

Most TNs today are assigned to specific geographies, at both an international level and within national numbering plans. Numbering practices today are tightly coupled with the manner that service providers interconnect, as well as how TNs are routed and administered: the PSTN was carefully designed to delegate switching intelligence geographically. In interexchange carrier routing in North America, for example, calls to a particular TN are often handed off to the terminating service provider close to the geography where that TN is assigned. But the overwhelming success of mobile telephones has increasingly eroded the connection between numbers and regions. Furthermore, the topology of IP networks is not anchored to geography in the same way that the telephone network is. In an Internet environment, establishing a network architecture for routing TNs could depend little on geography, relying instead on network topologies or other architectural features. Adapting TNs to the Internet requires more security, richer datasets and more complex query and response capabilities than previous efforts have provided.

This document attempts to create a common understanding of the problem statement related to allocating, managing, and resolving TNs in an IP environment. It outlines a framework and lists motivating use cases for creating IP-based mechanisms for TNs. It is important to acknowledge at the outset that there are various evolving international and national policies and processes related to TNs, and any solutions need to be flexible enough to account for variations in policy and requirements.

2. Definitions

This section provides definitions for actors, data types and data management architectures as they are discussed in this document. Different numbering spaces may instantiate these roles and concepts differently: practices that apply to non-geographic freephone numbers, for example, may not apply to geographic numbers, and

practices that exist under one Numbering Authority may not be permitted under another. The purpose of this framework is to identify the characteristics of protocol tools that will satisfy the diverse requirements for telephone number acquisition, management, and retrieval on the Internet.

2.1. Actors

The following roles of actors are defined in this document:

Numbering Authority: A regulatory body within a country that manages that country's TNs. The Numbering Authority decides national numbering policy for the nation, region, or other domain for which it has authority, including what TNs can be allocated, which are reserved, and which entities may obtain TNs.

Registry: An entity that administers the allocation of TNs based on a Numbering Authority's policies. Numbering authorities can act as the Registries themselves, or they can outsource the function to other entities. Traditional registries are single entities with sole authority and responsibility for specific numbering resources, though distributed registries (see Section 2.3) are also in the scope of this framework.

Registrar: An entity that distributes the telephone numbers administered by a Registry; typically, there are many Registrars that can distribute numbers from a single Registry, though Registrars may serve multiple Registries as well. A Registrar has business relationships with number assignees (defined below) and collects administrative information from them.

Communication Service Provider (CSP): A provider of communications services, where those services can be identified by TNs. This includes both traditional telephone carriers or enterprises as well as service providers with no presence on the PSTN who use TNs. This framework does not assume that any single CSP provides all the communications service related to a particular TN.

Service Enabler: An entity that works with CSPs to enable communication service to a User; perhaps a vendor, a service bureau, or third-party integrator.

User: An individual reachable through a communications service; usually a customer of a communication service provider.

Government Entity: An entity that, due to legal powers deriving from national policy, has privileged access to information about number administration under certain conditions.

Note that an individual, organization, or other entity may act in one or more of the roles above; for example, a company may be a CSP and also a Registrar. Although Numbering Authorities are listed as actors, they are unlikely to actually participate in the protocol flows themselves, though in some situations a Numbering Authority and Registry may be the same administrative entity.

All actors that are recipients of numbering resources, be they a CSP, Service Enabler, or User, can also be said to have a relationship to a Registry of either an assignee or delegate:

Assignee: An actor that is assigned a TN directly by a Registrar; an assignee always has a direct relationship with a Registrar.

Delegate: An actor that is delegated a TN from an assignee or another delegate, who does not necessarily have a direct relationship with a Registrar. Delegates may delegate one or more of their TN assignment(s) to one or more further downstream subdelegates.

As an example, consider a case where a Numbering Authority also acts as a Registry, and it issues 10,000 blocks of TNs to CSPs, which in this case also act as Registrars. CSP/Registrars would then be responsible for distributing numbering resources to Users and other CSPs. In this case, an enterprise deploying IP PBXs also acts as a CSP, and it acquires number blocks for its enterprise seats in chunks of 100 from a CSP acting as a Registrar with whom the enterprise has a business relationship. The enterprise is in this case the assignee, as it receives numbering resources directly from a Registrar. As it doles out individual numbers to its Users, the enterprise delegates its own numbering resources to those Users and their communications endpoints. The overall ecosystem might look as follows.

```
+---------+
|Numbering|
|Authority|Registry
+----+----+
     |
     V 10,000 TNs
+---------+
|   CSP   |Registrar
+----+----+
     |
     V  100 TNs
+---------+
|   PBX   |Assignee
+---------+
     |
     V    1 TN
+---------+
|  User   |Delegate
+---------+
```

Figure 1: Chain of Number Assignment

2.2. Data Types

The following data types are defined in this document:

Administrative Data: assignment data related to the TN and the relevant actors; it includes TN status (assigned, unassigned, etc.), contact data for the assignee or delegate, and typically does not require real-time access as this data is not required for ordinary call or session establishment.

Service Data: data necessary to enable service for the TN; it includes addressing data and service features. Since this data is necessary to complete calls, it must be obtained in real time.

Administrative and service data can fit into three categories:

Public: Anyone can access public data. Such data might include a list of which numbering resources (unallocated number ranges) are available for acquisition from the Registry.

Semi-restricted: Only a subset of actors can access semi-restricted data. For example CSPs may be able to access other CSP's service data.

Restricted: Only a small subset of actors can access restricted data. For example a Government Entity may be able access contact information for a User.

While it might appear there are really only two categories, public and restricted based on requestor, the distinction between semi-restricted and restricted is helpful for the use cases below.

2.3. Data Management Architectures

This framework generally assumes that administrative and service data is maintained by CSPs, Registrars, and Registries. The terms "registrar" and "registry" are familiar from DNS operations, and indeed the DNS provides an obvious inspiration for the relationships between those entities described here. Protocols for transferring names between registries and registrars have been standardized in the DNS space for some time (see [14]). Similarly, the division between service data acquired by resolving names with the DNS protocol vs. administrative data about names acquired through WHOIS [15] is directly analogous to the distinction between service and administrative data described in Section 2.2. The major difference between the data management architecture of the DNS and this framework is that the distinction between the CSP and User, due to historical policies of the telephone network, will often not exactly correspond to the distinction between a name service and a registrant in the DNS world - a User in the telephone network is today at least rarely in a direct relationship with a Registrar comparable to that of a DNS registrant.

The role of a Registry described here is a "thin" one, where the Registry manages basic allocation information for the numbering space, such as information about whether or not the number is assigned, and if assigned, by which Registrar. It is the Registrar that in turn manages detailed administrative data about those assignments, such as contact or billing information for the assignee. In some models, CSPs and Registrars will be combined (the same administrative entity), and in others the Registry and Registrar may similarly be composed. Typically, service data resides largely at the CSP itself, though in some models a "thicker" Registry may itself contain a pointer to the servicing CSP for a number or number block. In addition to traditional centralized Registries, this framework also supports environments where the same data is being managed by multiple administrative entities, and stored in many locations. A distributed registry system is discussed further in [19]. To support those use cases, it is important to distinguish the following:

Data store: A Data Store is a service that stores and enables access to administrative and/or service data.

Reference Address: A Reference Address is a URL that dereferences to the location of the data store.

Distributed data stores: In a Distributed Data Store, administrative or service data can be stored with multiple actors. For example, CSPs could provision their service data to multiple other CSPs.

Distributed Registries: Multiple Registries can manage the same numbering resource. In these architectures, actors could interact with one or multiple Registries. The Registries would update each other when change occurs. The Registries have to ensure that data remains consistent, e.g. that the same TN is not assigned to two different actors.

3. Framework

The framework outlined in this document requires three Internet-based mechanisms for managing and resolving telephone numbers (TNs) in an IP environment. These mechanisms will likely reuse existing protocols for sharing structured data; it is unlikely that new protocol development work will be required, though new information models specific to the data itself will be a major focus of framework development. Likely candidates for reuse here include work done in DRINKS [4] and WEIRDS [12], as well as the TeRI [16] framework.

These protocol mechanisms are scoped in a way that makes them likely to apply to a broad range of future policies for number administration. It is not the purpose of this framework to dictate number policy, but instead to provide tools that will work with policies as they evolve going forward. These mechanisms therefore do not assume that number administration is centralized, nor that number allocations are restricted to any category of service providers, though these tools must and will work in environments with those properties.

The three mechanisms are:

Acquisition: a protocol mechanism for acquiring TNs, including an enrollment process.

Management: a protocol mechanism for associating data with TNs.

Retrieval: a protocol mechanism for retrieving data about TNs.

The acquisition mechanism will enable actors to acquire TNs for use with a communications service by requesting numbering resources from a service operated by a Registrar, CSP or similar actor. TNs may be requested either on a number-by-number basis, or as inventory blocks.

Any actor who grants numbering resources will retain metadata about the assignment, including the responsible organization or individual to whom numbers have been assigned.

The management mechanism will let actors provision data associated with TNs. For example, if a User has been assigned a TN, they may select a CSP to provide a particular service associated with the TN, or a CSP may assign a TN to a User upon service activation. In either case, a mechanism is needed to provision data associated with the TN at that CSP, and to extend those data sets as CSPs (and even Users) require.

The retrieval mechanism will enable actors to learn information about TNs. For real-time service data, this typically involves sending a request to a CSP; for other information, an actor may need to send a request to a Registry rather than a CSP. Different parties may be authorized to receive different information about TNs.

As an example, a CSP might use the acquisition interface to acquire a chunk of numbers from a Registrar. Users might then provision administrative data associated with those numbers at the CSP through the management interface, and query for service data relating to those numbers through the retrieval interface of the CSP.

```
              +--------+
              |Registry|
              +---+----+
                  |
                  V
             +---------+
             |Registrar|
             +---------+
                   \
                    \\
          Acquisition \\
                        \\+-------+
                          \  CSP  |
                          +---+---+
                           A     A
                           |     |
                Management |     | Retrieval
                           |     |
                           |     |
                   +-------++   ++-------+
                   |  User  |   |  User  |
                   +--------+   +--------+
                   (delegate)    (caller)
```

Figure 2: Example of the Three Interfaces

4. Use Cases

The high-level use cases in this section will provide an overview of the expected operation of the three interfaces in the MODERN problem space:

4.1. Acquisition

There are various scenarios for how TNs can be acquired by the relevant actors, that is, a CSP, Service Enabler, and a User. There are three actors from which numbers can be acquired: a Registrar, a CSP and a User (presumably one who is delegating to another party). It is assumed that Registrars are either the same entity as Registries, or that Registrars have established business relationships with Registries that enable them to distribute the numbers that the Registries administer. In these use cases, a User may acquire TNs either from a CSP or a Registry, or from an intermediate delegate.

4.1.1. CSP Acquires TNs from Registrar

The most traditional number acquisition use case is one where a CSP, such as a carrier, requests a block of numbers from a Registrar to hold as inventory or assign to customers.

Through some out-of-band business process, a CSP develops a relationship with a Registrar. The Registrar maintains a profile of the CSP and assesses whether or not CSPs meet the policy restrictions for acquiring TNs. The CSP may then request TNs from within a specific pool of numbers in the authority of the Registry; such as region, mobile, wireline, or freephone. The Registrar must authenticate and authorize the CSP, and then either grant or deny a request. When an assignment occurs, the Registry creates and stores administrative information related to the assignment such as TN status and Registrar contact information, and removes the specific TN(s) from the pool of those that are available for assignment. As a part of the acquisition and assignment process, the Registry provides any necessary credentials (for example, STIR certificates [17]) to the Registrar to be used to prove the assignment for future transactions.

Before it is eligible to receive TN assignments, per the policy of a national authority, the CSP may need to have submitted (again, through some out-of-band process) additional qualifying information such as current utilization rate or a demand forecast.

There are two scenarios under which a CSP requests resources; they are requesting inventory, or they are requesting for a specific User or delegate. TNs assigned to a User are always considered assigned, not inventory. The CSP will associate service information for that TN, e.g., service address, and make it available to other CSPs to enable interconnection. The CSP may need to update the Registrar regarding this service activation; this is part of the "TN status" maintained by the Registrar.

4.1.2. User Acquires TNs from CSP

Today, a User typically acquires a TN from CSP when signing up for communications service or turning on a new device. In this use case, the User becomes the delegate of the CSP.

A User creates or has a relationship with the CSP, and subscribes to a communications service which includes the use of a TN. The CSP collects and stores administrative data about the User. The CSP then activates the User on their network and creates any necessary service data to enable connectivity with other CSPs. The CSP could also update public or privileged databases accessible by other Actors.

The CSP provides any necessary credentials to the User (for example, a STIR certificate [17]) to prove the assignment for future transactions. Such credential could be delegated from the one provided by the Registrar to the CSP to continue the chain of assignment.

The CSP could assign a TN from its existing inventory or it could acquire a new TN from the Registrar as part of the assignment process. If it assigns it from its existing inventory, it would remove the specific TN from the pool of those available for assignment. It may also update the Registrar about the assignment so the Registrar has current assignment data.

4.1.3. CSP Delegates TNs to Another CSP

A reseller or a service bureau might acquire a block of numbers from a CSP to be issued to Users.

In this case, the delegate CSP (as defined in Section 2.1) has a business relationship with the assignee CSP. The assignee CSP collects and stores administrative data about the delegate. The assignee then activates the delegate on their network and creates any necessary service data to enable interconnection with other CSPs. The CSP could also update public or privileged databases accessible by other Actors. The CSP provides any necessary credentials to the delegate CSP (for example, a STIR certificate [17]) to prove the assignment for future transactions. Such credentials could be delegated from the one provided by the Registry to the CSP to continue the chain of assignment.

The CSP could assign a block from its existing inventory or it could acquire new TNs from the Registrar as part of the assignment process. If it assigns it from its existing inventory it would remove the specific TN from the pool of those available for assignment. It may also update the Registrar about the assignment so the Registrar has current assignment data. The delegate may have the same obligations to provide utilization data to the Registry as the assignee, per Section 4.1.1

4.1.4. User Acquires TNs from a Delegate

Acquiring a TN from a delegate follows the process in Section 4.1.2, as it should be similar to how a User acquires TNs from a CSP. But in this case, the delegate re-delegating the TNs would be performing functions done by the CSP, e.g., providing any credentials, collecting administrative data, or creative service data.

4.1.5. User Acquires TNs from Registrar

Today, a user wishing to acquire a freephone number may browse the existing inventory through one or more Registrars, comparing their prices and services. Each such Registrar either is a CSP, or has a business relationship with one or more CSPs to provide services for that freephone number.

Acquiring a TN from a Registrar follows the process in Section 4.1.1, as it should be similar to how a CSP acquires TNs from a Registrar. In this case, the User must establish some business relationship directly with a Registrar, similarly to how such functions are conducted today when Users purchase domain names. For the purpose of status information kept by the Registry, TNs assigned to a User are always considered assigned, not inventory.

In this use case, after receiving a number assignment from the Registrar, a User will then obtain communications service from a CSP, and provide to the CSP the TN to be used for that service. The CSP will associate service information for that TN, e.g., service address, and make it available to other CSPs to enable interconnection. The user will also need to inform the Registrar about this relationship (see Section 4.2.1.3).

4.2. Management

The management protocol mechanism is needed to associate administrative and service data with TNs, and may be used to refresh or rollover associated credentials.

4.2.1. Management of Administrative Data

Administrative data is primarily related to the status of the TN, its administrative contacts, and the actors involved in providing service to the TN. Protocol interactions for administrative data will therefore predominantly occur between CSPs and Users to the Registrar, or between Users and delegate CSPs to the CSP.

Some administrative data may be private, and would thus require special handling in a distributed data store model. Access to it does not require real-time performance therefore local caches are not necessary. And it will include sensitive information such as user and contact data.

Some of the data could lend itself to being publicly available, such as CSP and TN assignment status. In that case it would be deemed public information for the purposes of the retrieval interface.

4.2.1.1. CSP to Registrar

After a CSP acquires a TN or block of TNs from the Registrar (per Section 4.1.1 above), it then provides administrative data to the Registrar as a step in the acquisition process. The Registrar will authenticate the CSP and determine if the CSP is authorized to provision the administrative data for the TNs in question. The Registry will update the status of the TN, i.e., that it is unavailable for assignment. The Registrar will also maintain administrative data provided by the CSP.

Changes to this administrative data will not be frequent. Examples of changes would be terminating service (see Section 4.2.3.2), changing the name or address of a User or organization, or changing a CSP or delegate. Changes should be authenticated by a credential to prove administrative responsibility for the TN.

In a distributed Registry model, TN status, e.g., allocated, assigned, available, unavailable, would need to be provided to other Registries in real-time. Other administrative data could be sent to all Registries or other Registries could get a reference address to the host Registry's data store.

4.2.1.2. User to CSP

After a User acquires a TN or block of TNs from a CSP, the User will provide administrative data to the CSP. The CSP commonly acts as a Registrar in this case, maintaining the administrative data and only notifies the Registry of the change in TN status. In this case, the Registry maintains a reference address (see Section 2.3) to the CSP/ Registrar's administrative data store so relevant actors have the ability to access the data. Alternatively, a CSP could send the administrative data to an external Registrar to store. If there is a delegate between the CSP and user, they will have to ensure there is a mechanism for the delegate to update the CSP as change occurs.

4.2.1.3. User to Registrar

If the User has a direct relationship with the Registrar, then naturally the user could provision administrative data associated with their TN directly to the Registrar. This is the case, for example, with the freephone example, where a User has a business relationship with its freephone provider, and the freephone provider maintains account and billing data. While delegates may not ordinarily have a direct relationship to a Registrar, some environments as an optimization might want to support a model where the delegate updates the Registrar directly on changes, as opposed to sending that data to the CSP or through the CSP to the Registrar. As

stated already, the protocol should enable Users to acquire TNs directly from a Registrar, which Registrar may or may not also act as a CSP. In these cases the updates would be similar to that described in Section 4.2.1.1.

4.2.2. Management of Service Data

Service data is data required by an originating or intermediate CSP to enable communications service to a User: a SIP URI is an example of one service data element commonly used to route communications. CSPs typically create and manage service data, however, it is possible that delegates and Users could as well. For most use cases involving individual Users, it is anticipated that lower-level service information changes (such as an end-user device receiving a new IP address) would be communicated to CSPs via existing protocols. For example, the baseline SIP REGISTER [2] method, even for bulk operations [13], would likely be used rather than through any new interfaces defined by MODERN.

4.2.2.1. CSP to other CSPs

After a User enrolls for service with a CSP, in the case where the CSP was assigned the TN by a Registrar, the CSP will then create a service address such as a SIP URI and associate it with the TN. The CSP needs to update this data to enable service interoperability. There are multiple ways that this update can occur, though most commonly service data is exposed through the retrieval interface (see Section 4.3). For certain deployment architectures, like a distributed data store model, CSPs may need to provide data directly to other CSPs.

If the CSP is assigning a TN from its own inventory it may not need to perform service data updates as change occurs because the existing service data associated with inventory may be sufficient once the TN is put in service. They would however likely update the Registry on the change in status.

4.2.2.2. User to CSP

Users could also associate service data to their TNs at the CSP. An example is a User acquires a TN from the Registrar (as described in Section 4.1.5) and wants to provide that TN to the CSP so the CSP can enable service. In this case, once the user provides the number to the CSP, the CSP would update the Registry or other actors as outlined in Section 4.2.2.1.

4.2.3. Managing Change

This section will address some special use cases that were not covered in other sections of 4.2.

4.2.3.1. Changing the CSP for an Existing Communications Service

A User who subscribes to a communications service, and received their TN from that CSP, wishes to retain the same TN but move their service to a different CSP. The User provides their credential to the new CSP and the CSP initiates the change in service

In the simplest scenario, where there's an authoritative combined Registry/Registrar that maintains service data, the new CSP provides the new service data with the User's credential to the Registry/ Registrar, which then makes the change. The old credential is revoked and a new one is provided. The new CSP or the Registrar would send a notification to the old CSP, so they can disable service. The old CSP will undo any delegations to the User, including invalidating any cryptographic credentials (e.g., STIR certificates [13]) previously granted to the User. Any service data maintained by the CSP must be removed, and similarly, the CSP must delete any such information it provisioned in the Registry.

In a similar model to common practice in some environments today, the User could provide their credential to the old CSP, and the old CSP initiates the change in service. Alternatively, a User could go directly to a Registrar to initiate a port. The framework should support all of these potential flows.

Note that in cases with a distributed Registry that maintained service data, the Registry would also have to update the other Registries of the change.

4.2.3.2. Terminating a Service

A User who subscribes to a communications service, and received their TN from the CSP, wishes to terminate their service. At this time, the CSP will undo any delegations to the User, including invalidating any cryptographic credentials (e.g., STIR certificates [13]) previously granted to the User. Any service data maintained by the CSP must be removed, and similarly, the CSP must delete any such information it provisioned in the Registrar. However, per the policy of the Numbering Authority, Registrars and CSPs may be required to preserve historical data that will be accessible to Government Entities or others through audits, even if it is no longer retrievable through service interfaces.

The TN will change state from assigned to unassigned, the CSP will update the Registry. Depending on policies the TN could go back into the Registry, CSP, or delegate's pool of available TNs and would likely enter an ageing process.

In an alternative use case, a User who received their own TN assignment directly from a Registrar terminates their service with a CSP. At this time, the User might terminate their assignment from the Registrar, and return the TN to the Registry for re-assignment. Alternatively, they could retain the TN and elect to assign it to some other service at a later time.

4.3. Retrieval

Retrieval of administrative or service data will be subject to access restrictions based on the category of the specific data: public, semi-restricted or restricted. Both administrative and service data can have data elements that fall into each of these categories. It is expected that the majority of administrative and service data will fall into the semi-restricted category: access to this information may require some form of authorization, though service data crucial to reachability will need to be accessible. In some environments, it's possible that none of the service data will be considered public.

The retrieval protocol mechanism for semi-restricted and restricted data needs a way for the receiver of the request to identify the originator of the request and what is being requested. The receiver of the request will process that request based on this information.

4.3.1. Retrieval of Public Data

Under most circumstances, a CSP wants its communications service to be publicly reachable through TNs, so the retrieval interface supports public interfaces that permit clients to query for service data about a TN. Some service data may however require that the client be authorized to receive it, per the use case in Section 4.3.3 below.

Public data can simply be posted on websites or made available through a publicly available API. Public data hosted by a CSP may have a reference address at the Registry.

4.3.2. Retrieval of Semi-restricted Administrative Data

Consider a case in which a CSP is having service problems completing calls to a specific TN, so it wants to contact the CSP serving that TN. The Registry authorizes the originating CSP to access this

information. It initiates a query to the Registry, the Registry verifies the requestor and the requested data and Registry responds with the serving CSP and contact data.

Alternatively that information could be part of a distributed data store and not stored at the Registry. In that case, the CSP has the data in a local distributed data store and it initiates the query to the local data store. The local data store responds with the CSP and contact data. No verification is necessary because it was done when the CSP was authorized to receive the data store.

4.3.3. Retrieval of Semi-restricted Service Data

A User on a CSP's network calls a TN. The CSP initiates a query for service data associated with the TN to complete the call, and will receive special service data because the CSP operates in a closed environment where different CSPs receive different responses, and only authorized CSPs may access service data. The query and response must have real-time performance.

In a distributed data store model each CSP distributes its updated service data to all other CSPs. The originating CSP has the service data in its local data store and queries it. The local data store responds with the service data. The service data in the response can be a reference address to a data store maintained by the serving CSP, or it can be the service address itself. In the case where the response gives a reference address, a subsequent query would go to the serving CSP, who would in turn authorize the requestor for the requested data and respond appropriate. In the case where the original response contains the service address, the requestor would use that service address as the destination for the call.

In some environments, aspects of the service data may reside at the Registry itself (for example, the assigned CSP for a TN), and thus the query may be sent to the Registry. The Registry verifies the requestor and the requested data and responds with the service data, such as a SIP URI containing the domain of the assigned CSP.

4.3.4. Retrieval of Restricted Data

A Government Entity wishes to access information about a particular User, who subscribes to a communications service. The entity that operates the Registry on behalf of the National Authority in this case has some pre-defined relationship with the Government Entity. When the CSP acquired TNs from the National Authority, it was a condition of that assignment that the CSP provide access for Government Entities to telephone numbering data when certain

conditions apply. The required data may reside either in the CSP or in the Registrar.

For a case where the CSP delegates a number to the User, the CSP might provision the Registrar (or itself, if the CSP is composed with a Registrar) with information relevant to the User. At such a time as the Government Entity needs information about that User, the Government Entity may contact the Registrar or CSP to acquire the necessary data. The interfaces necessary for this will be the same as those described in Section 4.3; the Government Entity will be authenticated, and an authorization decision will be made by the Registrar or CSP under the policy dictates established by the National Authority.

5. Acknowledgments

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6. IANA Considerations

This memo includes no instructions for the IANA.

7. Security Considerations

The acquisition, management, and retrieval of administrative and service data associated with telephone numbers raises a number of security issues.

Any mechanism that allows an individual or organization to acquire telephone numbers will require a means of mutual authentication, of integrity protection, and of confidentiality. A Registry as defined in this document will surely want to authenticate the source of an acquisition request as a first step in the authorization process to determine whether or not the resource will be granted. Integrity of both the request and response is essential to ensuring that tampering does not allow attackers to block acquisitions, or worse, to commandeer resources. Confidentiality is essential to preventing eavesdroppers from learning about allocations, including the personally identifying information associated with the administrative or technical contracts for allocations.

A management interface for telephone numbers has similar requirements. Without proper authentication and authorization mechanisms in place, an attack could use the management interface to disrupt service data or administrative data, which could deny service

to users, enable new impersonation attacks, prevent billing systems from operating properly, and cause similar system failures.

Finally, a retrieval interfaces has its own needs for mutual authentication, integrity protection, and for confidentiality. Any CSP sending a request to retrieve service data associated with a number will want to know that it is reaching the proper authority, that the response from that authority has not been tampered with in transit, and in most cases the CSP will not want to reveal to eavesdroppers the number it is requesting or the response that it has received. Similarly, any service answering such a query will want to have a means of authenticating the source of the query, and of protecting the integrity and confidentiality of its responses.

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