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Location-to-URL Mapping Architecture and Framework
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Abstract

This document describes an architecture for a global, scalable, resilient and administratively distributed system for mapping geographic location information to URLs, using the Location-to-Service (LoST) protocol. The architecture generalizes well-known approaches found in hierarchical lookup systems such as DNS.

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1. Introduction

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It is often desirable to allow users to access a service that provides a common function, but is actually offered by a variety of local service providers. In many of these cases, the service provider chosen depends on the location of the person wishing to access that service. Among the best-known public services of this kind is emergency calling, where emergency calls are routed to the most appropriate public safety answering point (PSAP), based on the caller's physical location. Other services, from food delivery to directory services and roadside assistance, also follow this general pattern. This is a mapping problem (Schulzrinne, H. and R. Marshall, “Requirements for Emergency Context Resolution with Internet Technologies,” January 2008.) [RFC5012], where a geographic location and a service identifier (URN) (Schulzrinne, H., “A Uniform Resource Name (URN) for Emergency and Other Well-Known Services,” January 2008.) [RFC5031] is translated into a set of URIs, the service URIs, that allow the Internet system to contact an appropriate network entity that provides the service.
The caller does not need to know where the service is being provided from, and the location of the service provider may change over time,

e.g., to deal with temporary overloads, failures in the primary service provider location or long-term changes in system architecture. For emergency services, this problem is described in more detail in [I-D.ietf-ecrit-framework] (Rosen, B., Schulzrinne, H., Polk, J., and A. Newton, “Framework for Emergency Calling using Internet Multimedia,” July 2009.).

The overall emergency calling architecture (Rosen, B., Schulzrinne, H., Polk, J., and A. Newton, “Framework for Emergency Calling using Internet Multimedia,” July 2009.) [I-D.ietf-ecrit-framework] separates mapping from placing calls or otherwise invoking the service, so the same mechanism can be used to verify that a mapping exists ("address validation") or to obtain test service URIs.

Mapping locations to URIs describing services requires a distributed, scalable and highly resilient infrastructure. Authoritative knowledge about such mappings is distributed among a large number of autonomous entities that may have no direct knowledge of each other. In this document, we describe an architecture for such a global service. It allows significant freedom to combine and split functionality among actual servers and imposes few requirements as to who should operate particular services.

Besides determining the service URI, end systems also need to determine the local service numbers. As discussed in Section 9 (Configuring Service Numbers), the architecture described here can also address that problem.

The architecture described here uses the Location-to-Service Translation (LoST) (Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, “LoST: A Location-to-Service Translation Protocol,” August 2008.) [RFC5222] protocol, although much of the discussion would also apply for other mapping protocols satisfying the mapping requirements (Schulzrinne, H. and R. Marshall, “Requirements for Emergency Context Resolution with Internet Technologies,” January 2008.) [RFC5012].

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2. Terminology

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The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 (Bradner, S., “Key words for use in RFCs to Indicate Requirement Levels,” March 1997.) [RFC2119] and indicate requirement levels for compliant implementations.

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3. Definitions

In addition to the terms defined in [RFC5012] (Schulzrinne, H. and R. Marshall, "Requirements for Emergency Context Resolution with Internet Technologies," January 2008.), this document uses the following terms to describe LoST clients and servers:

authoritative mapping server (AMS): An authoritative mapping server (AMS) is a LoST server that can provide the authoritative answer to a particular set of queries, e.g., covering a set of PIDF-LO civic labels or a particular region described by a geometric shape. In some (rare) cases of territorial disputes, two resolvers may be authoritative for the same region. An AMS may redirect or forward a query to another AMS within the tree.

child: A child is an AMS that is authoritative for a subregion of another AMS. A child can in turn be parent for another AMS.

(tree node) cluster: A node cluster is a group of LoST servers that all share the same mapping information and return the same results for queries. Clusters provide redundancy and share query load. Clusters are fully-meshed, i.e., they all exchange updates with each other.

coverage region: The coverage region of an AMS is the geographic region within which the AMS is able to authoritatively answer mapping queries. Coverage regions are generally, but not

necessarily, contigous and may be represented as either a subset of a civic address or a geometric object.

forest guide (FG): A forest guide (FG) has knowledge of the coverage region of trees for a particular top-level service.

mapping: A mapping is a short-hand for 'mapping from a location object to one or more URLs describing either another mapping server or the desired service URLs'.

parent: A mapping server that covers the region of all of its children. A mapping server without a parent is a root AMS.

resolver: A resolver is contacted by a seeker, consults a forest mapping server and then resolves the query using an appropriate tree. Resolvers may cache query results.

seeker: A seeker is a LoST client requesting a mapping. A seeker does not provide mapping services to others, but may cache results for its own use.

tree: A tree consists of a self-contained hierarchy of authoritative mapping servers for a particular service. Each tree exports its coverage region to the forest mapping servers.

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4. Overview of Architecture

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4.1. The Principal Components

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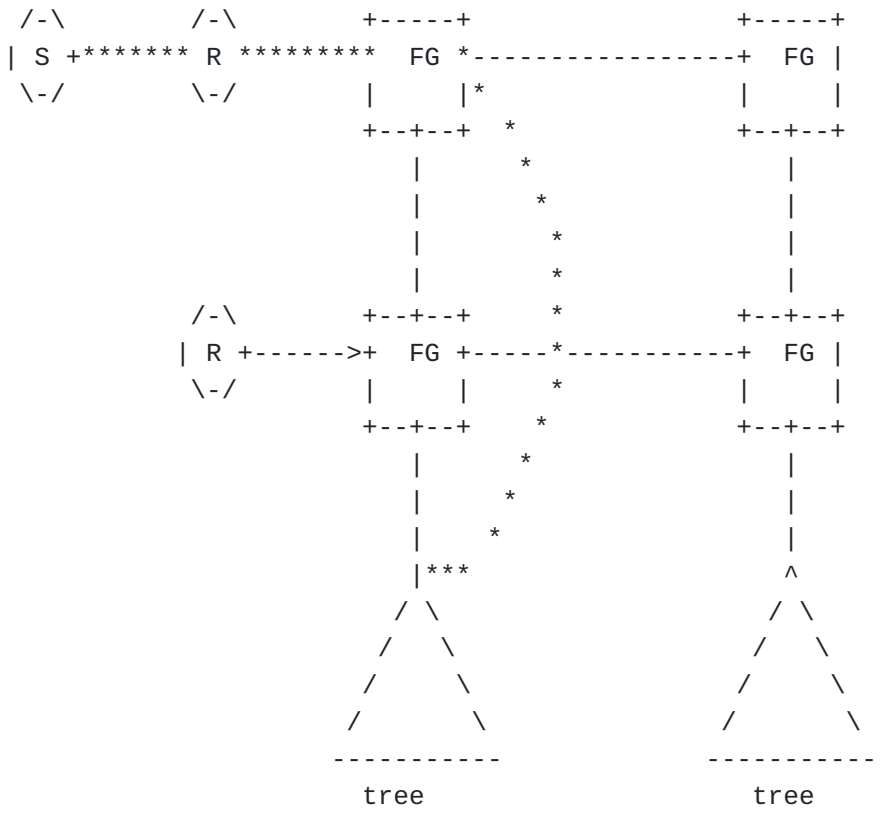
The mapping architecture distinguishes four logical roles: seekers, resolvers, authoritative mapping servers (AMS) and forest guides (FGs). End users of the LoST-based (Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, “LoST: A Location-to-Service Translation Protocol,” August 2008.) [RFC5222] mapping mechanism, called seekers, contact resolvers that cache query results and know one or more forest guides. Forest guides form the top level of a conceptual hierarchy, with one or more trees providing a hierarchical resolution service for different geographic regions. Forest guides know the geographic coverage region of all or almost all trees and direct queries to the node at the top of the appropriate tree. Trees consist of authoritative mapping servers and maintain the authoritative mapping information.

Seekers, resolvers, authoritative mapping servers and forest guides all communicate using LoST; indeed, it is likely that in many cases, the same software can operate as a resolver, authoritative mapping server and forest guide. In addition to the basic LoST query protocol (Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, "LoST: A Location-to-Service Translation Protocol," August 2008.) [RFC5222], a synchronization protocol (Schulzrinne, H., "Synchronizing Location-to-Service Translation (LoST) Servers," February 2008.) [I-D.schulzrinne-ecrit-lost-sync] may be used to exchange information between forest guides or to push coverage information from a tree node to its parent.

Seekers may be part of VoIP or other end systems, or SIP proxies or similar call routing functions.

Figure 1 shows the interaction of the components. The lines indicating the connection between the forest guides are logical connections, indicating that they are synchronizing their information via the synchronization protocol (Schulzrinne, H., "Synchronizing Location-to-Service Translation (LoST) Servers," February 2008.) [I-D.schulzrinne-ecrit-lost-sync].



Architecture diagram, showing seekers (S), resolvers (R), forest guides (FG) and trees. The star (*) line indicates the flow of the query and

responses in recursive mode, while the lines indicate synchronization relationships.

Figure 1

The mapping function for the world is divided among trees. The collection of trees may not cover the whole world and trees are added and removed as the organization of mapping data changes. We call the collection of trees a forest. There is no limit on the number of trees within the forest, but the author guesses that the number of trees will likely be somewhere between a few hundred and a few thousand. The lower estimate would apply if each country operates one tree, the higher if different governmental or private organizations within a country operate independent trees. We assume that tree coverage information changes relatively slowly, on the order of less than one change per year per tree, although the system imposes no specific threshold. Tree coverage would change, for example, if a country is split or merged or if two trees for different regions become part of a larger tree. (On the other hand, information within a tree is likely to change much more frequently.)

4.2. Minimal System Architecture

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It is possible to build a functioning system consisting only of seekers and resolvers if these resolvers have other means of obtaining mapping data. For example, a company acting as a mapping service provider could collect mapping records manually and make them available to their customers through the resolver. While feasible as a starting point, such an architecture is unlikely to scale globally. Among other problems, it becomes very hard for providers of authoritative data to ensure that all such providers have up-to-date information. If new trees are set up, they would somehow make themselves known to these providers. Such a mechanism would be similar to the old "hosts.txt" mechanism for distributing host information in the early Internet before DNS was developed.
Below, we describe the operation of each component in more detail.

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5. Seeker

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Clients desiring location-to-service mappings are known as seekers. Seekers are consumers of mapping data and originate LoST queries as LoST protocol clients. Seekers do not answer LoST queries. They contact either forest guides or resolvers to find the appropriate tree that can

authoritatively answer their questions. Seekers can be end systems such as SIP user agents or call routing entities such as SIP proxy servers. Seekers may need to obtain mapping information in several steps, i.e., they may obtain pointers to intermediate servers that lead them closer to the final mapping. Seekers MAY cache query results for later use, but otherwise have no obligations to other entities in the system. Seekers need to be able to identify appropriate resolvers. The mechanism for providing seekers with that information is likely to differ depending on who operates the resolvers. For example, if the voice service provider operates the resolver, it might include the location of the resolver in the SIP configuration information it distributes to its user agents. An Internet access provider or enterprise can provide a pointer to a resolver via DHCP [RFC5223] (Schulzrinne, H., Polk, J., and H. Tschofenig, "Discovering Location-to-Service Translation (LoST) Servers Using the Dynamic Host Configuration Protocol (DHCP)," August 2008.). In an ad-hoc or zero-configuration environment, appropriate service directories may advertise resolvers.

Like other entities in the system, seekers can cache responses. This is particularly useful if the response describes the result for a civic or geospatial region, rather than just a point. For example, for mobile nodes, seekers would only have to update their resolution results when they leave the coverage area of a service provider, such as a PSAP for emergency services, and can avoid repeatedly polling for this information whenever the location information changes slightly. (Mobile nodes would also need a location update mechanism that is either local or triggered when they leave the current service area.) This will likely be of particular benefit for seekers representing a large user population, such as the outbound proxy in a corporate network. For example, rather than having to query separately for each cubicle, information provided by the authoritative node may indicate that the whole campus is covered by the same service provider.

Given this caching mechanism and cache lifetimes of several days, most mobile users traveling to and from work would only need to obtain service area information along their commute route once during each cache lifetime.

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6. Resolver

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A seeker can contact a forest guide (see below) directly, but may not be able to easily locate such a guide. In addition, seekers in the same geographic area may already have asked the same question. Thus, it makes sense to introduce another entity, known as a resolver in the architecture, that knows how to contact one or more forest guides and caches earlier queries to accelerate the response to mapping queries and to improve the resiliency of the system. Each resolver can decide

autonomously which FGs to use, with possibly different choices for each top-level service.
ISPs or VSPs may include the address of a suitable resolver in their configuration information, e.g., in SIP configuration for a VSP or DHCP [RFC5223] (Schulzrinne, H., Polk, J., and H. Tschofenig, “Discovering Location-to-Service Translation (LoST) Servers Using the Dynamic Host Configuration Protocol (DHCP),” August 2008.) for an ISP. Resolvers are manually configured with the name of one or more forest guides.

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7. Trees: Maintaining Authoritative Knowledge

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7.1. Basic Operation

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The architecture assumes that authoritative knowledge about the mapping data is distributed among many independent administrative entities, but clients (seekers) may potentially need to find out mapping information for any spot on earth. (Extensions to extra-terrestrial applications are left for future exploration.) Information is organized hierarchically, in a tree, with tree nodes representing larger geographic areas pointing to several child nodes each representing a smaller area. Each tree node can be a cluster of LoST servers that all contain the same information and back up each other.
Each tree can map a location described by either civic or geographic coordinates, but not both, for one type of service (such as 'sos.police', 'sos.fire' or 'counseling'), although nothing prevents re-using the same servers for multiple different services or both types of coordinates. The collection of all trees for one service is known as a forest.
Each tree root announces its coverage region to one or more forest guides.
Each tree node cluster knows the coverage region of its children and sends queries to the appropriate server "down" the tree. Each such tree node knows authoritatively about the service mappings for a particular region, typically, but not necessarily, contiguous. The region can be described by any of the shapes in the LoST specification expressed in geospatial coordinates, such as circles or polygons, or a set of civic address descriptors (e.g., "country = DE, A1 = Bavaria"). These coverage regions may be aligned with political boundaries, but that is not required. In most cases, to avoid confusion, only one cluster is responsible for a particular geographic or civic location, but the system can also deal with cases where coverage regions overlap.
There are no assumptions about the coverage region of a tree as a whole. For example, a tree could cover a single city, or a state/

province or a whole country. Nodes within a tree need to loosely coordinate their operation, but they do not need to be operated by the same administrator.

The tree architecture is roughly similar to the domain name system (DNS), except that delegation is not by label, but rather by region. (Naturally, DNS does not have the notion of forest guides.) One can also draw analogies to LDAP, when deployed in a distributed fashion. Tree nodes maintain two types of information, namely coverage regions and mappings. Coverage regions describe the region served by a child node in the tree and point to a child node for further resolution. Mappings contain an actual service URI leading to a service provider or another signaling server representing a group of service providers, which in turn might further route signaling requests to more servers covering smaller regions.

Leaf nodes, i.e., nodes without children, only maintain mappings, while tree nodes above the leaf nodes only maintain coverage regions. An example for emergency services of a leaf node entry is shown below, indicating how queries for three towns are directed to different PSAPs. Queries for Englewood are directed to another LoST server instead.

```
country   A1 A2         A3         resource or LoST server
US        NJ Bergen     Leonia     sip:psap@leonianj.gov
US        NJ Bergen     Fort Lee   sip:emergency@fortleenj.org
US        NJ Bergen     Teaneck    sip:police@teanecknjgov.org
US        NJ Bergen     Englewood  englewoodnj.gov
....
```

Coverage regions are described by sets of LoST-compatible shapes enclosing contiguous geographic areas or by descriptors enumerating groups of civic locations. For the former, the LoST server performs the same matching operation as described in Section 12.2 of the LoST specification (Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, “LoST: A Location-to-Service Translation Protocol,” August 2008.) [RFC5222] to find the tree or AMS.

As a civic location example, a state-level tree node for New Jersey in the United States may contain the coverage region entries shown below, indicating that any query matching a location in Bergen County, for example, would be redirected or forwarded to the node located at bergen.nj.example.org.

There is no requirement that all child nodes cover the same level within the civic hierarchy. As an example, in the table below, the city of Newark has decided to be listed directly within the state node, rather than through the county. Longest-match rules allow partial coverage, so that for queries for all other towns within Essex county would be directed to the county node for further resolution.

```
C  A1 A2         A3     LoST server name
US NJ Atlantic   *      atlantic.nj.example.org/sos
US NJ Bergen     *      bergen.nj.example.org/sos
US NJ Monmouth   *      monmouth.nj.example.org/sos
US NJ Essex      *      essex.nj.example.org/sos
US NJ Essex      Newark newark.example.com/sos
....
```

Thus, there is no substantial difference between coverage region and mapping data. The only difference is that coverage regions return names of LoST servers, while mapping entries contain service URLs. Mapping entries may be specific down to the house or floor level or may only contain street-level information. For example, in the United States, civic mapping data for emergency services is generally limited to address ranges ("MSAG data"), so initial mapping databases may only contain street-level information.

To automate the maintenance of trees, the LoST synchronization mechanism (Schulzrinne, H., "Synchronizing Location-to-Service Translation (LoST) Servers," February 2008.) [I-D.schulzrinne-ecrit-lost-sync] allows nodes to query other nodes for mapping data and coverage regions, both within a cluster and across different hierarchy levels in a tree. In the example above, the state-run node would query the county nodes and use the records returned to distribute incoming LoST queries to the county nodes. Conversely, nodes could also contact their parent nodes to tell them about their coverage region. There is some benefit of child nodes contacting their parents, as this allows changes in coverage region to propagate quickly up the tree.

7.2. Answering Queries

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Within a tree, the basic operation is straightforward: A query reaches the root of the tree. That node determines which coverage region matches that request and forwards the request to the URL indicated in the coverage region record, returning a response to the querier when it in turns receives an answer (recursion). Alternatively, the node returns the URL of that child node to the querier (iteration). This process applies to each node, i.e., a node does not need to know whether the original query came from a parent node, a seeker, a forest guide or a resolver.

For efficiency, a node MAY return region information instead of a point answer. Thus, instead of returning that a particular geospatial coordinate maps to a service or mapping URL, it MAY return a polygon indicating the region for which this answer would be returned, along

with expiration time (time-to-live) information. The querying node can then cache this information for future use.
For civic coordinates, trees may not include individual mapping records for each floor, house number or street. To avoid giving the wrong indication that a particular location has been found valid, LoST can indicate which parts of the location information have actually been used to look up a mapping.

7.3. Overlapping Coverage Regions

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In some cases, coverage regions may overlap, either because there is a dispute as to who handles a particular geographic region or, more likely, since the resolution of the coverage map may not be sufficiently high. For example, a node may "shave some corners" off its polygon, so that its coverage region appears to overlap with its geographic neighbor. For civic coordinates, houses on the same street may be served by different PSAPs. The mapping mechanism needs to work even if a coverage map is imprecise or if there are disputes about coverage.
The solution for overlapping coverage regions is relatively simple. If a query matches multiple coverage regions, the node returns all URLs, in redirection mode, or queries both children, if in recursive mode. If the overlapping coverage is caused by imprecise coverage maps, only one will return a result and the others will return an error indication. If the particular location is disputed territory, the response will contain all answers, leaving it to the querier to choose the preferred solution or trying to contact all services in turn.

7.4. Scaling and Reliability

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Since they provide authoritative information, tree nodes need to be highly reliable. Thus, while this document refers to tree nodes as logical entities within the tree, an actual implementation would likely replicate node information across several servers, forming a cluster. Each such node would have the same information. Standard techniques such as DNS SRV records can be used to select one of the servers. Replication within the cluster can use any suitable protocol mechanism, but a standardized incremental update mechanism makes it easier to spread those nodes across multiple independently-administered locations. The techniques developed for meshed SLP (Zhao, W., Schulzrinne, H., and E. Guttman, “Mesh-enhanced Service Location Protocol (mSLP),” April 2003.) [RFC3528] are applicable here.

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8. Forest Guides

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Unfortunately, just having trees covering various regions of the world is not sufficient as a client of the mapping protocol would not generally be able to keep track of all the trees in the forest. To facilitate orientation among the trees, we introduce a forest guide (FG) which keeps track of the coverage regions of all the trees for one service. For scalability and reliability, there will need to be a large number of forest guides, all providing the same information. A seeker can contact a suitable forest guide and will then be directed to the right tree or, rarely, set of trees. Forest guides do not provide mapping information themselves, but rather redirect to mapping servers. In some configurations, not all forest guides may provide the same information, due to policy reasons.

Forest guides fulfill a similar role to root servers in DNS. They distribute information, signed for authenticity, offered by trees. However, introducing forest guides avoids creating a global root, with the attendant management and control issues.

However, unlike DNS root servers, forest guides may offer different information based on local policy. Forest guides can also restrict their data synchronization to parts of the information. For example, if country C does not recognize country T, C can propagate tree regions for all but T.

For authenticity, the coverage regions SHOULD be digitally signed by the authorities responsible for the region, as discussed in more detail in Section 10 (Security Considerations). They are used by resolvers and possibly seekers to find the appropriate tree for a particular area.

All forest guides should have consistent information, i.e., a collection of all the coverage regions of all the trees. A tree node at the top of a tree can contact any forest guide and inject new coverage region information into the system. One would expect that each tree announces its coverage to more than one forest guide. Each forest guide peers with one or more other guides and distributes new coverage region announcements to other guides. Due to policy and maybe political reasons, not all forest guides may share the same coverage region data.

Forest guides can, in principle, be operated by anybody, including voice service providers, Internet access providers, dedicated services providers and enterprises.

As in routing, peering with other forest guides implies a certain amount of trust in the peer. Thus, peering is likely to require some negotiation between the administering parties concerned, rather than automatic configuration. The mechanism itself does not imply a particular policy as to who gets to advertise a particular coverage region.

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9. Configuring Service Numbers

The section below is not directly related to the problem of determining service location, but is an instance of the more generic problem solved by this architecture, namely mapping location information to service-related parameters, such as service numbers.

For the foreseeable future, some user devices and software will emulate the user interface of a telephone, i.e., the only way to enter call address information is via a 12-button keypad with digits and the asterisk and hash symbol. These devices use service numbers to identify services. The best-known examples of service numbers are emergency numbers, such as 9-1-1 in North America and 1-1-2 in Europe. However, many other public and private service numbers have been defined, ranging in the United States from 3-1-1 for non-emergency local government services to 4-1-1 for directory assistance to various "800" numbers for anything from roadside assistance to legal services to home-delivery food.

Such service numbers are likely to be used until essentially all communication devices feature IP connectivity and an alphanumeric keyboard. Unfortunately, for emergency services, more than 60 emergency numbers are in use throughout the world, with many of those numbers serving non-emergency purposes elsewhere, e.g., identifying repair or directory services. Countries also occasionally change their emergency numbers to conform to regional agreements. An example is the introduction of "1-1-2" for countries in Europe.

Thus, a system that allows devices to be used internationally to place calls needs to allow devices to discover service numbers automatically. In the Internet-based system proposed here (Rosen, B., Schulzrinne, H., Polk, J., and A. Newton, “Framework for Emergency Calling using Internet Multimedia,” July 2009.) [I-D.ietf-ecrit-framework], these numbers are strictly used as a human user interface mechanism and are generally not visible in call signaling messages, which carry the service URN (Schulzrinne, H., “A Uniform Resource Name (URN) for Emergency and Other Well-Known Services,” January 2008.) [RFC5031] instead.

For the best user experience, systems should be able to discover two sets of service numbers, namely those used in the user's home country and in the country the user is currently visiting. The user is most likely to remember the former, but a companion borrowing a device in an emergency, say, may only know the local emergency numbers.

Determining home and local service numbers is a configuration problem, but unfortunately, existing configuration mechanisms are ill-suited for this purpose. For example, a DHCP server might be able to provide the local service numbers, but not the home numbers. When virtual private networks (VPNs) are used, even DHCP may provide numbers of uncertain origin, as a user may contact the home network or some local branch office of the corporate network. Similarly, SIP configuration (Channabasappa, S., “A Framework for Session Initiation Protocol User Agent Profile Delivery,” February 2010.)

[I-D.ietf-sipping-config-framework] would be able to provide the numbers valid at the location of the SIP service provider, but even a SIP service provider with national footprint may serve customers that are visiting any number of other countries.
Also, while initially there are likely to be only a few service numbers, e.g., for emergency services, the LoST architecture can be used to support other services, as noted. Configuring every local DHCP or SIP configuration server with that information is likely to be error-prone and tedious.
For these reasons, the LoST-based mapping architecture supports providing service numbers to end systems based on caller location. The mapping operation is almost exactly the same as for determining the service URL. The mapping can be obtained either along with the service URL or through a separate request. The major difference between the two requests is that service numbers often have much larger regions of validity than the service URL itself. Also, the service number is likely to be valid longer than the service URL. Finally, an end system may want to look up the service number for its home location, not just its current (visited) location.

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10. Security Considerations

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Security considerations for emergency services mapping are discussed in [RFC5069] (Taylor, T., Tschofenig, H., Schulzrinne, H., and M. Shanmugam, “Security Threats and Requirements for Emergency Call Marking and Mapping,” January 2008.), while [RFC5031] (Schulzrinne, H., “A Uniform Resource Name (URN) for Emergency and Other Well-Known Services,” January 2008.) discusses issues related to the service URN, one of the inputs into the mapping protocol. LoST-related security considerations are naturally discussed in the LoST (Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, “LoST: A Location-to-Service Translation Protocol,” August 2008.) [RFC5222] specification.
The architecture addresses the following security issues, usually through the underlying transport security associations:

Server impersonation: Seekers, resolvers, fellow tree guides and cluster members can assure themselves of the identity of the remote party by using the facilities in the underlying channel security mechanism, such as TLS (Dierks, T. and E. Rescorla, “The Transport Layer Security (TLS) Protocol Version 1.2,” August 2008.) [RFC5246].

Query or query result corruption: To avoid that an attacker can modify the query or its result, the architecture RECOMMENDS the use of channel security, such as TLS. Results SHOULD also be digitally signed, e.g., using XML digital signatures (Eastlake,

D., Solo, D., and J. Reagle, “XML-Signature Syntax and Processing,” February 2002.) [W3C.REC-xmldsig-core-20020212]. Note, however, that simple origin assertion may not provide the end system with enough useful information as it has no good way of knowing that a particular signer is authorized to represent a particular geographic area. It might be necessary that certain well-known Certificate Authorities (CAs) vet sources of mapping information and provide special certificates for that purpose. In many cases, a seeker will have to trust its local resolver to vet information for trustworthiness; in turn, the resolver may rely on trusted forest guides to steer it to the correct information.

Coverage region corruption: To avoid that a third party or an untrustworthy member of a server population claims a coverage region that it is not authorized for, any node introducing a new region map MUST sign the object by protecting the data with an XML digital signature (Eastlake, D., Solo, D., and J. Reagle, “XML-Signature Syntax and Processing,” February 2002.) [W3C.REC-xmldsig-core-20020212]. A recipient MUST verify, through a local policy mechanism, that the signing entity is indeed authorized to speak for that region. Determining who can speak for a particular region is inherently difficult unless there is a small set of authorizing entities that participants in the mapping architecture can trust. Receiving systems should be particularly suspicious if an existing coverage region is replaced with a new one with a new mapping address. In many cases, trust will be mediated: A seeker will have a trust relationship with a resolver. The resolver, in turn, will contact a trusted forest guide.

Additional threats that need to be addressed by operational measures include denial-of-service attacks [I-D.ietf-ecrit-phonebcp] (Rosen, B. and J. Polk, “Best Current Practice for Communications Services in support of Emergency Calling,” January 2010.).

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11. IANA Considerations

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Since this document describes an architecture, not a protocol, it does not ask IANA to register any protocol constants.

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12. Acknowledgments

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