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LISP Threats Analysis
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Abstract

This document provides a threat analysis of the Locator/Identifier Separation Protocol (LISP).

Status of this Memo

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1. Introduction

The Locator/ID Separation Protocol (LISP) is specified in [RFC6830]. This document provides an assessment of the potential security threats for the current LISP specifications if LISP is deployed in the Internet (i.e., a public non-trustable environment).

The document is composed of three main parts: the first defines a general threat model that attackers use to mount attacks. The second part, using this threat model, describes the techniques based on the LISP protocol and LISP architecture that attackers may use to construct attacks. The third part discusses mitigation techniques and general solutions to protect the LISP protocol and architecture from attacks.

This document does not consider all the possible uses of LISP as discussed in [RFC6830] and [RFC7215]. The document focuses on LISP unicast, including as well LISP Interworking [RFC6832], LISP Map-Server [RFC6833]), and LISP Map-Versioning [RFC6834]. The reader is assumed to be familiar with these documents for understanding the present document.

This document assumes a generic IP service and does not discuss the difference, from a security viewpoint, between using IPv4 or IPv6.

2. Threat model

This document assumes that attackers can be located anywhere in the Internet (either in LISP sites or outside LISP sites) and that attacks can be mounted either by a single attacker or by the collusion of several attackers.

An attacker is a malicious entity that performs the action of attacking a target in a network where LISP is (partially) deployed by leveraging the LISP protocol and/or architecture.

An attack is the action of performing an illegitimate action on a target in a network where LISP is (partially) deployed.

The target of an attack is the entity (i.e., a device connected to the network or a network) that is aimed to undergo the consequences of an attack. Other entities can potentially undergo side effects of an attack, even though they are not directly targeted by the attack. The target of an attack can be selected specifically, i.e., a particular entity, or arbitrarily, i.e., any entity. Finally, an attacker can aim at attacking one or several targets with a single attack.

Section 2.1 specifies the different modes of operation that attackers can follow to mount attacks and Section 2.2 specifies the different categories of attacks that attackers can build.

2.1. Attacker's Operation Modes

Attackers can be classified according to the following four modes of operation, i.e., the temporal and spacial diversity of the attacker.

2.1.1. On-path vs. Off-path Attackers

On-path attackers, also known as Men-in-the-Middle, are able to intercept and modify packets between legitimate communicating entities. On-path attackers are located either directly on the normal communication path (either by gaining access to a node on the path or by placing themselves directly on the path) or outside the location path but manage to deviate (or gain a copy of) packets sent between the communication entities. On-path attackers hence mount their attacks by modifying packets initially sent legitimately between communication entities.

An attacker is called off-path attacker if it does not have access to packets exchanged during the communication or if there is no communication. In order for their attacks to succeed, off-path attackers must hence generate packets and inject them in the network.

2.1.2. Internal vs. External Attackers

An internal attacker launches its attack from a node located within a legitimate LISP site. Such an attacker is either a legitimate node of the site or it exploits a vulnerability to gain access to a legitimate node in the site. Because of their location, internal attackers are trusted by the site they are in.

On the contrary, an external attacker launches its attacks from the outside of a legitimate LISP site.

2.1.3. Live vs. Time-shifted attackers

A live attacker mounts attacks for which it must remain connected as long as the attack is mounted. In other words, the attacker must remain active for the whole duration of the attack. Consequently, the attack ends as soon as the attacker (or the used attack vector) is neutralized.

On the contrary, a time-shifted attacker mounts attacks that remain active after it disconnects from the Internet.

2.1.4. Control-plane vs. Data-plane attackers

A control-plane attacker mounts its attack by using control-plane functionalities, typically the mapping system.

A data-plane attacker mounts its attack by using data-plane functionalities.

As there is no complete isolation between the control-plane and the data-plane, an attacker can operate in the control-plane (or data-plane) to mount attacks targeting the data-plane (or control-plane) or keep the attacked and targeted planes at the same layer (i.e., from control-plane to control-plane or from data-plane to data-plane).

2.1.5. Cross mode attackers

The attacker modes of operation are not mutually exclusive and hence attackers can combine them to mount attacks.

For example, an attacker can launch an attack using the control-plane directly from within a LISP site to which it is able to get temporary access (i.e., internal + control-plane attacker) to create a vulnerability on its target and later on (i.e., time-shifted + external attacker) mount an attack on the data plane (i.e., data-plane attacker) that leverages the vulnerability.

2.2. Threat categories

Attacks can be classified according to the nine following categories.

2.2.1. Replay attack

A replay attack happens when an attacker retransmits at a later time, and without modifying it, a packet (or a sequence of packets) that has already been transmitted.

2.2.2. Packet manipulation

A packet manipulation attack happens when an attacker receives a packet, modifies the packet (i.e., changes some information contained in the packet) and finally transmits the packet to its final destination that can be the initial destination of the packet or a different one.

2.2.3. Packet interception and suppression

In a packet interception and suppression attack, the attacker captures the packet and drops it before it can reach its final destination.

2.2.4. Spoofing

With a spoofing attack, the attacker injects packets in the network pretending to be another node. Spoofing attacks are made by forging source addresses in packets.

It should be noted that with LISP, packet spoofing is similar to spoofing with any other existing tunneling technology currently deployed in the Internet. Generally the term "spoofed packet" indicates a packet containing a source IP address that is not the actual originator of the packet. Hence, since LISP uses encapsulation, the spoofed address could be in the outer header as well as in the inner header, this translates to two types of spoofing.

Inner address spoofing: the attacker uses encapsulation and uses a spoofed source address in the inner packet. In case of data-plane LISP encapsulation, that corresponds to spoofing the source EID (End-point IDentifier) address of the encapsulated packet.

Outer address spoofing: the attacker does not use encapsulation and spoofs the source address of the packet. In case of data-plane LISP encapsulation, that corresponds to spoofing the source RLOC (Routing LOCator) address of the encapsulated packet.

Note that the two types of spoofing are not mutually exclusive, rather all combinations are possible and could be used to perform different kinds of attacks. For example, an attacker outside a LISP site can generate a packet with a forged source IP address (i.e., outer address spoofing) and forward it to a LISP destination. The packet is then eventually encapsulated by a PITR (Proxy Ingress Tunnel Router) so that once encapsulated the attack corresponds to a inner address spoofing. One can also imagine an attacker forging a packet with encapsulation where both inner and outer source addresses are spoofed.

It is important to note that the combination of inner and outer spoofing makes the identification of the attacker complex as the packet may not contain information that allows to detect the origin of the attack.

2.2.5. Rogue attack

In a rogue attack the attacker manages to appear as a legitimate source of information, without faking its identity (as opposed to a spoofing attacker).

2.2.6. Denial of Service (DoS) attack

A Denial of Service (DoS) attack aims at disrupting a specific targeted service to make it unable to operate properly.

2.2.7. Performance attack

A performance attacks aims at exploiting computational resources (e.g., memory, processor) of a targeted node so as to make it unable to operate properly.

2.2.8. Intrusion attack

In an intrusion attack, the attacker gains remote access to a resource (e.g., a host, a router, or a network) or information that it legitimately should not have access. Intrusion attacks can lead to privacy leakages.

2.2.9. Amplification attack

In an amplification attack, the traffic generated by the target of the attack in response to the attack is larger than the traffic that the attacker must generate.

In some cases, the data-plane can be several orders of magnitude faster than the control-plane at processing packets. This difference can be exploited to overload the control-plane via the data-plane without overloading the data-plane.

2.2.10. Multi-category attacks

Attacks categories are not mutually exclusive and any combination can be used to perform specific attacks.

For example, one can mount a rogue attack to perform a performance attack starving the memory of an ITR (Ingress Tunnel Router) resulting in a DoS (Denial-of-Service) on the ITR.

3. Attack vectors

This section presents attack techniques that may be used by attackers

when leveraging the LISP protocol and/or architecture.

3.1. Gleaning

To reduce the time required to obtain a mapping, the optional gleaning mechanism defined for LISP allows an xTR (Ingress and/or Egress Tunnel Router) to directly learn a mapping from the LISP data encapsulated packets and the Map-Request packets that it receives. LISP encapsulated data packets contain a source RLOC, destination RLOC, source EID and destination EID. When an xTR receives an encapsulated data packet coming from a source EID for which it does not already know a mapping, it may insert the mapping between the source RLOC and the source EID in its EID-to-RLOC Cache. The same technique can be used when an xTR receives a Map-Request as the Map-Request also contains a source EID address and a source RLOC. Once a gleaned entry has been added to the EID-to-RLOC cache, the xTR sends a Map-Request to retrieve the actual mapping for the gleaned EID from the mapping system.

If a packet injected by an off-path attacker and with a spoofed inner address is gleaned by an xTR then the attacker may divert the traffic meant to be delivered to the spoofed EID as long as the gleaned entry is used by the xTR. This attack can be used as part of replay, packet manipulation, packet interception and suppression, or DoS attacks as the packets are sent to the attacker.

If the packet sent by the attacker contains a spoofed outer address instead of a spoofed inner address then it can achieve a DoS or a performance attack as the traffic normally destined to the attacker will be redirected to the spoofed source RLOC. Such traffic may overload the owner of the spoofed source RLOC, preventing it from operating properly.

If the packet injected uses both inner and outer spoofing, the attacker can achieve a spoofing, a performance, or an amplification attack as traffic normally destined to the spoofed EID address will be sent to the spoofed RLOC address. If the attacked LISP site also generates traffic to the spoofed EID address, such traffic may have a positive amplification factor.

A gleaning attack does not only impact the data-plane but can also have repercussions on the control-plane as a Map-Request is sent after the creation of a gleaned entry. The attacker can then achieve DoS and performance attacks on the control-plane. For example, if an attacker sends a packet for each address of a prefix not yet cached in the EID-to-RLOC cache of an xTR, the xTR will potentially send a Map-Request for each such packet until the mapping is installed which leads to an over-utilisation of the control-plane as each packet

generates a control-plane event. In order for this attack to succeed, the attacker may not need to use spoofing. This issue can occur even if gleaning is turned off since whether or not gleaning is used as the ITR may need to send a Map-Request in response to incoming packets whose EID is not currently in the cache.

Gleaning attacks are fundamentally involving a time-shifted mode of operation as the attack may last as long as the gleaned entry is kept by the targeted xTR. RFC 6830 [RFC6830] recommends to store the gleaned entries for only a few seconds which limits the duration of the attack.

Gleaning attacks always involve external data-plane attackers but results in attacks on either the control-plane or data-plane.

Note, the outer spoofed address does not need to be the RLOC of a LISP site, it may be any address.

3.2. Locator Status Bits

When the L bit in the LISP header is set to 1, it indicates that the second 32-bits longword of the LISP header contains the Locator Status Bits. In this field, each bit position reflects the status of one of the RLOCs mapped to the source EID found in the encapsulated packet. The reaction of a LISP xTR that receives such a packet is left as operational choice in [RFC6830].

When an attacker sends a LISP encapsulated packet with an illegitimately crafted LSB to an xTR, it can influence the xTR's choice of the locators for the prefix associated to the source EID. In case of an off-path attacker, the attacker must inject a forged packet in the network with a spoofed inner address. An on-path attacker can manipulate the LSB of legitimate packets passing through it and hence does not need to use spoofing. Instead of manipulating the LSB field, an on-path attacker can also obtain the same result of injecting packets with invalid LSB values by replaying packets.

The LSB field can be leveraged to mount a DoS attack by either declaring all RLOCs as unreachable (all LSB set to 0), or by concentrating all the traffic to one RLOC (e.g., all but one LSB set to 0) and hence overloading the RLOC concentrating all the traffic from the xTR, or by forcing packets to be sent to RLOCs that are actually not reachable (e.g., invert LSB values).

The LSB field can also be used to mount a replay, a packet manipulation, or a packet interception and suppression attack. Indeed, if the attacker manages to be on the path between the xTR and one of the RLOCs specified in the mapping, forcing packets to go via

that RLOC implies that the attacker will gain access to the packets.

Attacks using the LSB are fundamentally involving a time-shifted mode of operation as the attack may last as long as the reachability information gathered from the LSB is used by the xTR to decide the RLOCs to be used.

3.3. Map-Version

When the Map-Version bit of the LISP header is set to 1, it indicates that the low-order 24 bits of the first 32 bits longword of the LISP header contain a Source and Destination Map-Version. When a LISP xTR receives a LISP encapsulated packet with the Map-Version bit set to 1, the following actions are taken:

- It compares the Destination Map-Version found in the header with the current version of its own configured EID-to-RLOC mapping, for the destination EID found in the encapsulated packet. If the received Destination Map-Version is smaller (i.e., older) than the current version, the ETR should apply the SMR (Solicit-Map-Request) procedure described in [RFC6830] and send a Map-Request with the SMR bit set.

- If a mapping exists in the EID-to-RLOC Cache for the source EID, then it compares the Map-Version of that entry with the Source Map-Version found in the header of the packet. If the stored mapping is older (i.e., the Map-Version is smaller) than the source version of the LISP encapsulated packet, the xTR should send a Map-Request for the source EID.

A cross-mode attacker can use the Map-Version bit to mount a DoS attack, an amplification attack, or a spoofing attack. For instance if the mapping cached at the xTR is outdated, the xTR will send a Map-Request to retrieve the new mapping which can yield to a DoS attack (by excess of signalling traffic) or an amplification attack if the data-plane packet sent by the attacker is smaller, or otherwise uses fewer resources, than the control-plane packets sent in response to the attacker's packet. With a spoofing attack, and if the xTR considers that the spoofed ITR has an outdated mapping, it will send an SMR to the spoofed ITR which can result in performance, amplification, or DoS attack as well.

Map-Version attackers are inherently cross mode as the Map-Version is a method to put control information in the data-plane. Moreover, this vector involves live attackers. Nevertheless, on-path attackers do not have specific advantage over off-path attackers.

3.4. Routing Locator Reachability

The Nonce-Present and Echo-Nonce bits in the LISP header are used to verify the reachability of an xTR. A testing xTR sets the Echo-Nonce and the Nonce-Present bits in LISP data encapsulated packets and include a random nonce in the LISP header of packets. Upon reception of these packets, the tested xTR stores the nonce and echoes it whenever it returns a LISP encapsulated data packets to the testing xTR. The reception of the echoed nonce confirms that the tested xTR is reachable.

An attacker can interfere with the reachability test by sending two different types of packets:

1. LISP data encapsulated packets with the Nonce-Present bit set and a random nonce. Such packets are normally used in response to a reachability test.

2. LISP data encapsulated packets with the Nonce-Present and the Echo-Nonce bits both set. These packets will force the receiving ETR to store the received nonce and echo it in the LISP encapsulated packets that it sends. These packets are normally used as a trigger for a reachability test.

The first type of packets are used to make xTRs think that an other xTR is reachable while it is not. It is hence a way to mount a DoS attack (i.e., the ITR will send its packet to a non-reachable ETR when it should use another one).

The second type of packets could be exploited to attack the nonce-based reachability test. If the attacker sends a continuous flow of packets that each have a different random nonce, the ETR that receives such packets will continuously change the nonce that it returns to the remote ITR, which can yield to a performance attack. If the remote ITR tries a nonce-reachability test, this test may fail because the ETR may echo an invalid nonce. This hence yields to a DoS attack.

In the case of an on-path attacker, a packet manipulation attack is necessary to mount the attack. To mount such an attack, an off-path attacker must mount an outer address spoofing attack.

If an xTR chooses to periodically check with active probes the liveness of entries in its EID-to-RLOC cache (as described in section 6.3 of [RFC6830]), then this may amplify the attack that caused the insertion of entries being checked.

3.5. Instance ID

LISP allows to carry in its header a 24-bits value called Instance ID and used on the ITR to indicate which local Instance ID has been used for encapsulation, while on the ETR the instance ID decides the forwarding table to use to forward the decapsulated packet in the LISP site.

An attacker (either a control-plane or data-plane attacker) can use the instance ID functionality to mount an intrusion attack.

3.6. Interworking

[RFC6832] defines Proxy-ITR and Proxy-ETR network elements to allow LISP and non-LISP sites to communicate. The Proxy-ITR has functionality similar to the ITR, however, its main purpose is to encapsulate packets arriving from the DFZ (Default-Free Zone) in order to reach LISP sites. A PETR (Proxy Egress Tunnel Router) has functionality similar to the ETR, however, its main purpose is to inject de-encapsulated packets in the DFZ in order to reach non-LISP sites from LISP sites. As a PITR (or PETR) is a particular case of ITR (or ETR), it is subject to similar attacks as ITRs (or ETRs).

As any other system relying on proxies, LISP interworking can be used by attackers to hide their exact origin in the network.

3.7. Map-Request messages

A control-plane off-path attacker can exploit Map-Request messages to mount DoS, performance, or amplification attacks. By sending Map-Request messages at high rate, the attacker can overload nodes involved in the mapping system. For instance sending Map-Requests at high rate can considerably increase the state maintained in a Map-Resolver or consume CPU cycles on ETRs that have to process the Map-Request packets they receive in their slow path (i.e., performance or DoS attack). When the Map-Reply packet is larger than the Map-Request sent by the attacker, that yields to an amplification attack. The attacker can combine the attack with a spoofing attack to overload the node to which the spoofed address is actually attached.

Note, if the attacker sets the P bit (Probe Bit) in the Map-Request, it will cause legitimately sending the Map-Request directly to the ETR instead of passing through the mapping system.

The SMR bit can be used to mount a variant of these attacks.

For efficiency reasons, Map-Records can be appended to Map-Request messages. When an xTR receives a Map-Request with appended Map-

Records, it does the same operations as for the other Map-Request messages and so is subject to the same attacks. However, it also installs in its EID-to-RLOC cache the Map-Records contained in the Map-Request. An attacker can then use this vector to force the installation of mappings in its target xTR. Consequently, the EID-to-RLOC cache of the xTR is polluted by potentially forged mappings allowing the attacker to mount any of the attacks categorized in Section 2.2 (see Section 3.8 for more details). Note, the attacker does not need to forge the mappings present in the Map-Request to achieve a performance or DoS attack. Indeed, if the attacker owns a large enough EID prefix it can de-aggregate it in many small prefixes, each corresponding to another mapping and it installs them in the xTR cache by mean of the Map-Request.

Moreover, attackers can use Map Resolver and/or Map Server network elements to relay its attacks and hide the origin of the attack. Indeed, on the one hand, a Map Resolver is used to dispatch Map-Request to the mapping system and, on the other hand, a Map Server is used to dispatch Map-Requests coming from the mapping system to ETRs that are authoritative for the EID in the Map-Request.

3.8. Map-Reply messages

Most of the security risks associated with Map-Reply messages will depend on the 64 bits nonce that is included in a Map-Request and returned in the Map-Reply. If an ETR does not accept Map-Reply messages with an invalid nonce, the risk of an off-path attack is limited given the size of the nonce (64 bits). Nevertheless, the nonce only confirms that the Map-Reply received was sent in response to a Map-Request sent, it does not validate the contents of that Map-Reply.

If an attacker manages to send a valid (i.e., in response to a Map-Request and with the correct nonce) Map-Reply to an ITR, then it can perform any of the attacks categorised in Section 2.2 as it can inject forged mappings directly in the ITR EID-to-RLOC cache. For instance, if the mapping injected to the ITR points to the address of a node controlled by the attacker, it can mount replay, packet manipulation, packet interception and suppression, or DoS attacks, as it will receive every packet destined to a destination lying in the EID prefix of the injected mapping. In addition, the attacker can inject a plethora of mappings in the ITR to mount a performance attack by filling up the EID-to-RLOC cache of the ITR. The attacker can also mount an amplification attack if the ITR at that time is sending a large number of packets to the EIDs matching the injected mapping. In this case, the RLOC address associated to the mapping is the address of the real target of the attacker and so all the traffic of the ITR will be sent to the target which means that with one

single packet the attacker may generate very high traffic towards its final target.

If the attacker is a valid ETR in the system, it can mount a rogue attack if it uses prefixes over-claiming. In such a scenario, the attacker ETR replies to a legitimate Map-Request message which it received with a Map-Reply message that contains an EID-Prefix that is larger than the prefix owned by the attacker. For example if the owned prefix is 192.0.2.0/25 but the Map-Reply contains a mapping for 192.0.2.0/24, then the mapping will influence packets destined to other EIDs than the one attacker has authority on. With such technique, the attacker can mount the attacks presented above as it can (partially) control the mappings installed on its target ITR. To force its target ITR to send a Map-Request, nothing prevents the attacker to initiate some communication with the ITR. This method can be used by internal attackers that want to control the mappings installed in their site. To that aim, they simply have to collude with an external attacker ready to over-claim prefixes on behalf of the internal attacker.

Note, when the Map-Reply is in response to a Map-Request sent via the mapping system (i.e., not send directly from the ITR to an ETR), the attacker does not need to use a spoofing attack to achieve its attack as by design the source IP address of a Map-Reply is not known in advance by the ITR.

Map-Request and Map-Reply messages are exposed to any type of attackers, on-path or off-path but also external or internal attackers. Also, even though they are control message, they can be leveraged by data-plane attackers. As the decision of removing mappings is based on the TTL indicated in the mapping, time-shifted attackers can take advantage of injecting forged mappings as well.

3.9. Map-Register messages

Map-Register messages are sent by ETRs to Map Servers to indicate to the mapping system the EID prefixes associated to them. The Map-Register message provides an EID prefix and the list of ETRs that are able to provide Map-Replies for the EID covered by the EID prefix.

As Map-Register messages are protected by an authentication mechanism, only a compromised ETR can register itself to its allocated Map Server.

A compromised ETR can over-claim the prefix it owns in order to influence the route followed by Map-Requests for EIDs outside the scope of its legitimate EID prefix (see Section 3.8 for the list of over-claiming attacks).

A compromised ETR can also de-aggregate its EID prefix in order to register more EID prefixes than necessary to its Map Servers (see Section 3.7 for the impact of de-aggregation of prefixes by an attacker).

Similarly, a compromised Map Server can accept an invalid registration or advertise an invalid EID prefix to the mapping system.

3.10. Map-Notify messages

Map-Notify messages are sent by a Map Server to an ETR to acknowledge the reception and processing of a Map-Register message.

Similarly to the pair Map-Request/Map-Reply, the pair Map-Register/ Map-Notify is protected by a nonce making it difficult for an attacker to inject a falsified notification to an ETR to make this ETR believe that the registration succeeded when it has not.

4. Note on Privacy

As reviewed in [RFC6973], universal privacy considerations are difficult to establish as the privacy definitions may vary for different scenarios. As a consequence, this document does not aim at identifying privacy issues related to the LISP protocol but the security threats identified in this document could play a role in privacy threats as defined in section 5 of [RFC6973].

Similar to public deployments of any other control plane protocols, in an Internet deployment, LISP mappings are public and hence provide information about the infrastructure and reachability of LISP sites (i.e., the addresses of the edge routers). Depending upon deployment details, LISP map replies might or might not provide finer grained and more detailed information than is available with currently deployed routing and control protocols.

5. Threats Mitigation

Most of the above threats can be mitigated with careful deployment and configuration (e.g., filter) and also by applying the general rules of security, e.g. only activating features that are necessary for the deployment and verifying the validity of the information obtained from third parties.

The control-plane is the most critical part of LISP from a security viewpoint and it is worth to notice that the LISP specifications

already offer an authentication mechanism for mappings registration ([RFC6833]). This mechanism, combined with LISP-SEC [I-D.ietf-lisp-sec], strongly mitigates threats in non-trustable environments such as the Internet. Moreover, an authentication data field for Map-Request messages and Encapsulated Control messages was allocated [RFC6830]. This field provides a general authentication mechanism technique for the LISP control-plane which future specifications may use while staying backward compatible. The usage will be designed and defined specific for the needs of the specification. The exact technique still has to be designed and defined. To maximally mitigate the threats on the mapping system, authentication must be used, whenever possible, for both Map-Request and Map-Reply messages and for messages exchanged internally among elements of the mapping system, such as specified in [I-D.ietf-lisp-sec] and [I-D.ietf-lisp-ddt].

Systematically applying filters and rate-limitation, as proposed in [RFC6830], will mitigate most of the threats presented in this document. In order to minimise the risk of overloading the control-plane with actions triggered from data-plane events, such actions should be rate limited.

Moreover, all information opportunistically learned (e.g., with LSB or gleaning) should be used with care until they are verified. For example, a reachability change learned with LSB should not be used directly to decide the destination RLOC, but instead should trigger a rate-limited reachability test. Similarly, a gleaned entry should be used only for the flow that triggered the gleaning procedure until the gleaned entry has been verified [Trilogy].

6. Security Considerations

This document provides a threat analysis and proposes mitigation techniques for the Locator/Identifier Separation Protocol.

7. IANA Considerations

This document makes no request to IANA.

8. Acknowledgments

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Appendix A. Document Change Log (to be removed on publication)

- Version 14 Posted December 2015.
  - Editorial changes according to Deborah Brungard's (Routing AD) review.
- Version 13 Posted August 2015.
  - Keepalive version.
- Version 12 Posted March 2015.
  - Addressed comments by Ross Callon on the mailing list (http://www.ietf.org/mail-archive/web/lisp/current/msg05829.html).
  - Addition of a section discussing mitigation techniques for deployments in non-trustable environments.

- Version 11 Posted December 2014.
  - Editorial polishing. Clarifications added in few points.
- Version 10 Posted July 2014.
  - Document completely remodelled according to the discussions on the mailing list in the thread http://www.ietf.org/mail-archive/web/lisp/current/msg05206.html and to address comments from Ronald Bonica and Ross Callon.
- Version 09 Posted March 2014.
  - Updated document according to the review of A. Cabellos.
- Version 08 Posted October 2013.
  - Addition of a privacy consideration note.
  - Editorial changes
- Version 07 Posted October 2013.
  - This version is updated according to the thorough review made during October 2013 LISP WG interim meeting.
  - Brief recommendations put in the security consideration section.
  - Editorial changes
- Version 06 Posted October 2013.
  - Complete restructuration, temporary version to be used at October 2013 interim meeting.
- Version 05 Posted August 2013.
  - Removal of severity levels to become a short recommendation to reduce the risk of the discussed threat.
- Version 04 Posted February 2013.
  - Clear statement that the document compares threats of public LISP deployments with threats in the current Internet architecture.

  * Addition of a severity level discussion at the end of each section.

  * Addressed comments from V. Ermagan and D. Lewis' reviews.

  * Updated References.

  * Further editorial polishing.

- Version 03 Posted October 2012.

  * Dropped Reference to RFC 2119 notation because it is not actually used in the document.

  * Deleted future plans section.

  * Updated References

  * Deleted/Modified sentences referring to the early status of the LISP WG and documents at the time of writing early versions of the document.

  * Further editorial polishing.

  * Fixed all ID nits.

- Version 02 Posted September 2012.

  * Added a new attack that combines over-claiming and de-aggregation (see Section 3.8).

  * Editorial polishing.

- Version 01 Posted February 2012.

  * Added discussion on LISP-DDT.

- Version 00 Posted July 2011.

  * Added discussion on LISP-MS>.

  * Added discussion on Instance ID.

  * Editorial polishing of the whole document.

  * Added "Change Log" appendix to keep track of main changes.

* Renamed "draft-saucez-lisp-security-03.txt.

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