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Privacy issues in Identifier/Locator Separation Systems
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Abstract

There exists several protocols and proposals that leverage on the Identifier/Locator split paradigm, having some form of control plane by which participating nodes can share their current Identifier-to-Location information with their peers. This document explores some of the privacy considerations for such a type of system.

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[1.](#) Introduction

When the IP address is separated, one way or another, into an identifier and a locator, there is typically the need to be able to look up an identifier to find possible locators which can be used to reach the identified endpoint. If such a system (think a distributed database) was publicly available, then this would introduce additional privacy considerations which do not exist in the absence of the ID/locator split. Think for instance if identifiers are assigned to devices such as mobile phones which have a strong binding with an individual. Having the location of such identifier publicly available implies make the individual whereabouts public.

Without an ID/locator split, a device is already providing its IP address (in the form of a source address) to any network device along the path, and also to the remote endpoint. That endpoint in particular might use IP geolocation databases to get a pretty good

idea of where its peer is located, for instance to offer information and/or advertising relevant to that location.

However, in such scenario, when a device (e.g., a laptop or smartphone connected over WiFi) moves (e.g., from home to a coffee shop) the IP address changes. This makes it harder for network devices along the paths to realize that it is the same mobile device. If the mobile device is not retaining cookies or logged into websites, those remote peers would also have some difficulty determining whether it is the same mobile device. Furthermore, a mobile device which is using typical cellular network technologies ends up with an IP address, at least as seen by remote peers outside of the cellular network, which is associated with the cellular operator but does not necessarily indicate a particular location of the mobile device.

Note that even if the IP address isn't always useful to track a mobile device today, there are several mechanisms higher in the stack which can do this. For instance cookies or SSL sessions, applications which share GPS location, or operators who offer additional location information (for instance based on which cellular base station a mobile device is using) to business partners.

Promising proposals leveraging on the Identifier Locator (Id-Loc) separation paradigm are: Identifier-Locator Network Protocol (ILNP) [[RFC6740](#)]; Locator/ID Separation Protocol (LISP) [[I-D.ietf-lisp-rfc6830bis](#)] [[I-D.ietf-lisp-rfc6833bis](#)]; Virtual eXtensible LAN [[RFC7348](#)]; Information-Centric Networking (ICN) [[RFC7927](#)]; Host Identity Protocol (HIP) [[RFC4423](#)]. Note that ICN does not leverage on IP addresses, however, the general architecture for this paradigm is based on a clear separation between content identifier and content location. Similarly, in HIP the identifier, while identifying representing a communication end-point it is not an IP address.

Architectures and protocols for these approaches are already

documented in detail and some are under continuous evolution in different WGs or RGs. This document on the other hand attempts to identify potential issues with respect to real-world deployment scenarios, which may demand for implementations of the above-mentioned Id-Loc systems. In particular, this document overviews issues related to threats due to privacy violation of devices and their users, as well as location detection and movement tracking, where specific countermeasures may be needed.

[2.](#) Keywords and Terminology

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

Identifier: An identifier is information allowing to unambiguously identify an entity or an entity group within a given scope. An identifier is the equivalent of an End-point Identifier (EID) in The Locator/ID Separation Protocol (LISP). It may or may not be visible in communications.

Locator: A locator is a routable network address. It may be associated with an identifier and used for communication on the network layer according to identifier locator split principle. A locator is the equivalent of a Routing Locator (RLOC) in LISP or an IP address in other cases.

[3.](#) Identifier Locator Separation and Privacy

Identifier represents a communication end-point, a content, or any identifiable entity and may not be a routable IP address, and in general it is not an IP address at all. Locator may represent a communication end-point, and in this case it usually is a routable network address. Because entities identified by an Identifier can move the association between Identifiers and Locators may be ephemeral. A database called a mapping system needs to be used for

Identifier to Locator mapping. Identifiers are mapped to locators for reachability purposes. A mapping system has to handle mobility by updating the identifier to locator mappings in the database. Note that different protocols/system may use a different terminology, however, the principle remains the same: a form of (ephemeral) binding between identifiers and locators.

To start the communication, a device needs to know the identifier of the destination, hence it relies on a identifier lookup process to obtain the associated locator(s). Note that both identifier and locator may be carried in clear in packet headers, depending on the specific technology used and the level of security/privacy enforced.

Usage of identifiers (and their locators) readily available for public access raises privacy issues. For public entities, it may be desirable to have their fully qualified domain names or host names available for public lookups by the clients. For private entities, usually the clients of the public ones, however, this is not the case. For instance for individuals roaming in a mobile network may

not want their locators publicly available, or may be only available to the members of his/her family.

Privacy is an increasingly desirable and often necessary property for Internet technologies.

[4.](#) Identifier Locator Split Protocols

Hereafter a non-exhaustive overview of protocol/system leveraging on the Locator/Identifier separation is provided.

[4.1.](#) Locator/Identifier Separation Protocol (LISP)

Locator/Id Separation Protocol (LISP) [[I-D.ietf-lisp-rfc6830bis](#)] [[I-D.ietf-lisp-rfc6833bis](#)] is based on a map-and-encap approach, which provides a level of indirection for routing and addressing performed at specific ingress/egress routers at the LISP domain boundaries. Such border routers performing LISP encapsulation at the packet's source stub network are indicated as Ingress Tunnel Routers (ITRs), while border routers at the packet's destination stub network are called Egress Tunnel Routers (ETRs), all of them are indicated by the general term xTRs. In order to obtain mappings used for

encapsulation operation, xTRs query the mapping system in order to obtain all mappings related to a certain EID only when necessary (usually, but not exclusively, at the beginning of a new flow transmission). The LISP control plane protocol [[I-D.ietf-lisp-rfc6833bis](#)] allows to support several different mapping systems (e.g., LISP+ALT [[RFC6836](#)] and LISP-DDT [[RFC8111](#)]). More than that, it can actually also be applied to various other data plane protocols.

[4.2.](#) Identifier/Locator Network Protocol (ILNP)

Identifier-Locator Network Protocol (ILNP) [[RFC6740](#)] is a host-based approach enabling mobility using mechanisms that are only deployed in end-systems and do not require any router changes.

[4.3.](#) Information Centric Networking (ICN)

Information-Centric Networking (ICN) [[RFC7927](#)] is an approach to evolve the Internet infrastructure to directly support information distribution by introducing uniquely named data as a core Internet principle. Data becomes independent from location, application, storage, and means of transportation, enabling or enhancing a number of desirable features, such as security, user mobility, multicast, and in-network caching.

[4.4.](#) Host Identity Protocol (HIP)

The Host Identity Protocol (HIP) [[RFC4423](#)] Architecture introduces a new namespace, namely the Host Identity namespace, and a new protocol. The HIP protocol aim at providing for limited forms of trust between systems, enhance mobility, multi-homing, and dynamic IP renumbering; aid in protocol translation/transition; and reduce certain types of denial-of-service (DoS) attacks.

[4.5.](#) Virtual eXtensible Local Area Network (VXLAN)

Virtual Extensible LAN (VXLAN) [[RFC7348](#)] is a network virtualization technology that attempts to address the scalability problems associated with large cloud computing deployments. It uses a VLAN-like encapsulation technique to encapsulate layer 2 Ethernet frames

within layer 4 UDP datagrams, using 4789 as the default IANA-assigned destination UDP port number. VXLAN endpoints, which terminate VXLAN tunnels and may be either virtual or physical switch ports, are known as VXLAN tunnel endpoints (VTEPs) and can be considered the locators of the devices in the extended VLAN.

[4.6.](#) Some Relevant Privacy-Critical Scenarios

The collection of scenarios shall serve as an overview of possible Loc/ID separation application and help in identifying different issues in privacy and security in generic Identifier Locator Split approaches.

[4.6.1.](#) Industrial IoT

Sensors and other connected things in the industry are usually not personal items (e.g. wearables) potentially revealing an individuals sensitive information. Yet, industrial connected objects are business assets whose information (e.g. location) should be available only to authorised intra-company entities. Hence, there is an interest in not shaing the ID/Locator binding with third parties, to retain the privacy. This can be achieved in a number of ways such as: using an ID/locator system but using some fixed anchor point as a locator; injecting routing prefixes for the ID prefixes into the normal routing system and use proxy indirection; providing limited ID/Locator exposure. These are just examples, more approaches should be explored in order to find which one is the most suitable in the context of industrial IoT.

[4.6.2.](#) 5G

Upcoming new truly universal communication via so-called 5G systems will demand for much more than (just) higher bandwidth and lower latency. Integration of heterogeneous multiple access technologies (both wireless and wireline) controlled by a common converged core network and the evolution to service-based flexile functionalities instead of hard-coded network functions calls for new protocols both

on control and user (data) plane. While Id-Loc approach would serve well here, the challenge to provide a unique level of security and privacy even for a lightweight routing and forwarding mechanism - allowing for ease of deployment and migration from existing operational network architecture - remains to be solved.

[4.6.3.](#) Cloud

The cloud, i.e. a set of distributed data centers for processing and storage connected via high-speed transmission paths, is seen as logical location for content and also for virtualized network function instances and shall provide measures for easy re-location and migration of these instances deployed as e.g. containers or virtual machines. Id-Loc split routing protocols are proposed for usage here as in VXLAN [[RFC7348](#)] and LISP [[I-D.ietf-lisp-rfc6830bis](#)] [[I-D.ietf-lisp-rfc6833bis](#)] while the topology of the cloud components and logical correlations shall be invisible from outside.

In a cloud, an upstream IP address does not necessarily belong to the actual service location, but a gateway or load balancer. So, the locator or also ID reveal the location with the accuracy of a data center, not the function taking a service request. This issue also manifests itself in today's LTE as PGWs are in a data center binding UEs' IP addresses which are from the network of the data center.

[5.](#) Threats against Privacy

There seems to be at least two different privacy threats relating to ID/locator mapping systems:

1. Location Privacy
2. Movement Privacy

Note that these threats appear in the hypothesis that the ID does not change. Nevertheless, even in the case of mutable IDs, there are other forms of information correlation that may allow to identify network entities.

[5.1.](#) Location Privacy

If a third party can at any time determine the IP location of some identifier, then the device can at one point be IP geolocated at home, and later a coffee shop.

[5.2.](#) Movement Privacy

If a third party can determine that an identifier has changed locator(s) at time T , then even without knowing the particular locators before and after, it can correlate this movement event with other information (e.g., security cameras) to create a binding between the identifier and a person.

[6.](#) Not everybody all the time

In order to see the benefits about but minimizing the privacy implication one can explore limiting to which peers and when the ID/locator binding are exposed.

A few initial examples help illustrate this.

[6.1.](#) Optimized Routing

If some operator of a network where there is a large amount of mobility wants to ensure efficient routing, then a ID/locator split approach might make sense. Such a system can potentially be limited to the set of devices (routers etc) which are under the operators control. If this is the case, then the ID/locator mapping system can provide access control so that only those trusted devices can access the mappings.

Note that from a privacy perspective this isn't any different than the same operator using a link-state routing protocol to share host routes for all the mobile devices. In that case all participants in the link-state protocol can determine the location (attached to which router) and notice any mobility events. Of course, there are significant non-privacy differences between those two approaches.

Exposing the ID/locator mapping to attached devices (e.g., any mobile devices which wouldn't be trusted to participate in the link-state routing counterpart approach), will change the privacy implications.

[6.2.](#) Family and Friends

There are cases where it is quite reasonable to share location information with other family members or friends. For instance, young children might run applications which enable their parents to

track them on their way to/from school. And I might share my location with friends so we can more easily find each other while out on town.

Today such location sharing happens at an application layer using GPS coordinates. But while such sharing is in effect, it wouldn't be unreasonable to also consider sharing IP locators to make it more efficient or more robust to e.g., route a video feed from one device to another.

[6.3.](#) Business Assets

In the area of Industrial IoT there are cases where an asset owner might want to ensure that their assets can communicate efficiently and robustly. In many cases those assets might be decoupled from any persons, but there can still be strong reasons to not share the ID/locator binding with third parties, such as enabling competitors to determine the number of deployed devices in a particular IP prefix.

[7.](#) Boundary between ID/locator part and rest of Internet

If the access to the ID/locator mapping are restricted as suggested above, then most of the potential peer devices would not have access to the ID/locator mappings. This means that there has to be a demarcation point between the part of the network which can access the ID/locator mappings for a particular identifier and the one which can not. There might be several choices how to handle this such as still using an ID/locator system but pointing a locator for some fixed anchor point, or injecting routing prefixes for the ID prefixes into the normal routing system, or not providing any stable locators across this boundary; only allow ephemeral IP addresses per session or otherwise limited exposure.

[8.](#) Security Considerations

This document discusses privacy considerations, but does not explore any security considerations.

[9.](#) IANA Considerations

There are no IANA actions needed for this document.

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