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L. Deng
China Mobile
R. Huang
Huawei
S. Duan
CATR
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Use-cases for Collaborative LMAP
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Abstract

This document discusses the motivation and use-cases for collaborative LMAP practices, where multiple autonomous measurement systems collaborate together in performing large scale performance measurements to help with QoE enhancement by ICPs, network performance monitor to guide ISP/Regulator coordination between autonomous network domains and/or regulatory policies and cross-boundary troubleshooting for complaints from end consumers.

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1 Introduction

With the rapid development of Internet technology and the increasing complexity of broadband network architecture, it is becoming difficult to do large scale network measurements due to the lack of the unified measurement system and cooperative protocols. Therefore, the Large-Scale Measurement of Broadband Performance (LMAP) working group is formed to standardize a large scale measurement system for the performance measurements of all kinds of broadband access methods.

There are 3 types of entities proposed in the LMAP architecture: [I-D.ietf-lmap-framework]

- o Measurement Agents (MAs), implemented in network to perform measurement tasks;
- o Controller, responsible for creating and assigning the measurement tasks; and
- o Collector, in charge of collecting and storing measurement results.

LMAP's current focus is to specify the information model, the associated data models, the control protocol for the secure communication between Controller and MA, and the report protocol for the secure communication between MA and Collector.

On the other hand, for a large network, collaboration between multiple Controllers may also be needed for performing local measurement tasks, either because there is a practical limit on the number of MAs a single Controller can manage simultaneously for scalability considerations, because that a local task may involve multiple MAs that are speaking different languages (i.e. different control/report protocols), or because different organizations want to interconnect their measurement systems.

Current LMAP protocols are designed under the following assumptions.

- o All the involved entities are under the control of a single organization.
- o An MA can only be controlled by a single controller at any given time.

- o There is no communication between Controllers, between Collectors, or between a Controller and a Collector.

However, cross-organization collaborations are increasingly common. For example, accurate troubleshooting for mobile services usually involves two or more organizations, and end-to-end performance measurement may be conducted across multiple ISPs. How to utilize LMAP practice to address these scenarios is still unsolved.

This document discusses the motivation and use-cases for collaborative LMAP practices, where multiple autonomous measurement systems collaborate together to help with QoE enhancement by ICPs, network performance monitoring to guide planning for network infrastructure and cross-boundary troubleshooting for SLA complaints from end consumers, as well as performing regulatory supervision by national regulators.

2 Terminology

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 [RFC2119].

The following acronyms are used extensively in this document.

- o ICP, Internet Content Provider.
- o QoE, Quality of Experience.
- o QoS, Quality of Service.
- o ISP, Internet Service Provider, or shortly Operator.
- o SLA, Service Level Agreement.
- o UE, User Equipment.
- o MAN, Metro Area Network.
- o WAN, Wide Area Network.

The following definitions are borrowed from LMAP framework [I-D.ietf-lmap-framework], and used to describe the corresponding entities within a participating LMAP system.

- o Controller: A function that provides a Measurement Agent with its Instruction.

- o Collector: A function that receives a Report from a Measurement Agent.
- o Measurement Agent (MA): The function that receives Instruction Messages from a Controller and operates the Instruction by executing Measurement Tasks (using protocols outside the initial LMAP work scope and perhaps in concert with one or more other Measurement Agents or Measurement Peers) and (if part of the Instruction) by reporting Measurement Results to a Collector or Collectors.
- o Measurement Method: The process for assessing the value of a Metric; the process of measuring some performance or reliability parameter associated with the transfer of traffic.
- o Measurement Task: The action performed by a particular Measurement Agent that consists of the single assessment of a Metric through operation of a Measurement Method role at a particular time, with all of the role's Input Parameters set to specific values.
- o Measurement Result: The output of a single Measurement Task (the value obtained for the parameter of interest or Metric).
- o Metric: The quantity related to the performance and reliability of the network that we'd like to know the value of.

The following definitions are used in this document to describe corresponding entities for a collaborative performance measurement among multiple LMAP systems.

- o Initiator, the instructor for collaborative Measurement Tasks, potentially on behalf of a regulator, a third party ICPs or an end consumer.
- o Reporter, the reporting party that aggregates partial Measurements Reports from collaborative LMAP task participants and produces the ultimate report to the task Initiator.
- o Region, a geographical area or administrative domain under the regulation of a single regulator.
- o Domain, a collection of network devices and their interconnections under the operation of a single administrative entity.

3 Motivations for Collaborative LMAP

End-to-end performance measurement and trouble-shooting are important

for multiple parties, including: (1) Internet Service Providers, in solving end user's QoE issues by better managing and optimizing their networks, (2) Internet Content Providers, for enhance its service logic and application design, (3) regulators in examining the status of and guiding future regulation.

From ISP's perspective, the importance of supporting LMAP for its own network construction and operation is without doubt. But taken into account the potential impact of introducing third-party LMAP MAS into key network entities, a sensible ISP would prefer to build its own LMAP system based on MAS embedded into its local network devices.

It is hence expected that the majority of end-to-end performance measurements will be conducted in a collaborative manner involving multiple autonomous LMAP systems, for the following reasons:

On one hand, for the regulator, in order to stimulate network development, it is necessary to have a clear picture of ISPs' peering performance for interconnection points in addition to their own local network construction. Considering the prohibitive cost of a unified third-party deployment for LMAP MAS at various peering links among ISPs for a large geographic area, it may be more practical to make use of ISPs' autonomous LMAP systems for collaboration.

Let us take the example in China for instance. China's networks are complex, with more than 31 provinces and 300 regions come to hierarchical networks deployments. There are 3 ISP giants (CMCC, CTCC, CUCC) in mainland China, managing nationwide hierarchical networks, each is consisted of 3-4 national center points for interconnecting on the top, more than 30 provincial backbone networks in the middle, and more than 300 regions' local networks on the bottom. In other words, the national regulator must know the network status of the 3 networks in each region of a province, of a province, and finally the whole country. It would be prohibitive for the national regulator authority, MIIT to deploy its own dedicated probes nationwide(900+).

Furthermore, regulators in different countries may want to interconnect their measurement systems to perform cross-border measurements.

On the other hand, for the ICP or user, it does not help much for service optimization or trouble shooting if the end-to-end performance measurement is conducted via a simple client-server model while treating the network as a black box. In the meantime, for the purpose of providing more value-added service to the ICPs as well as subscribers, there is motive for an ISP to open its LMAP system to

some extent and collaborate with the ICP/user in understanding the bottleneck and exploiting better network servicing for end-to-end QoE.

In the following sections, more specific use-cases and derived requirements of collaborative LMAP practices for end-to-end performance measurement are presented.

4 Use-cases for Collaborative LMAP

As stated above, there are motivations from the regulator, ISP/ICP and users to conduct collaborative measurements at the different levels in order to know if the current network conditions meet the expectations from the regulator policy, the ISP's resource provision agreement or the ICP's service provision agreement. In particular, the following usecases are identified.

4.1 Use-cases for Regulators

A regulator may want to monitor the current status and the future deployment of network construction and operation of its region. In order to promote network development, the regulator needs to monitor the status of interconnection between different ISPs as well as the overall network status.

4.1.1 within a regulator's own region

Understanding the current situation of its own region is necessary for a regulator to form guiding policies for stimulating further growth in high-speed networks. In order to get a clear picture of a large geographic area, the regulator may choose to not deploy a dedicated LMAP system on its own, while it's necessary to deploy a large number of MAs. The regulator may achieve this goal by means of the ISP's LMAP and the third-party LMAPs.

In that case, multiple organizations would simultaneously deploy their dedicated MAs for private LMAP systems within their network boundary in the same region, and by combining them together a measurement system can mainly cover the whole region's network infrastructure. Through collaboration, MAs from multiple organizations can perform comprehensive measurement for the whole regional network in great depth, which can reflect the network's operational state.

4.1.2 peering performance between ISPs

Low performance of peering links between different ISPs not only has great impact on ICP services, but also on an access ISPs relying on transit ISPs for Internet connectivity. For example, a mobile operator lacking access to an Internet resource will have to pay interconnections to other operators. The regulator can formulate policies to promote information sharing between ISP networks and investigate the user QoE problem by understanding the interconnection performance. For the same reason, an ISP/ICP can also benefit from a more clear understanding of the performance of the interconnection.

For example, the data flow for a service request from a mobile terminal to an ICP first goes through the access ISP network and then into the Internet via a transit ISP network. Similarly, before entering the ICP's own private data-center, it may traverse another transit ISP network. As shown in Figure 1, the measurement can be implemented between ISP#1 MA and ISP#2 MA to understand the interconnection quality.

UE<=>access ISP<=>transit ISP #1<=>Internet<=>transit ISP #2<=>ICP

Figure 1 Cross-Domain data flow path

In a single administrative domain, there are also scenarios for collaborative measurement.

4.2 Use-cases for the ISP

4.2.1 measurements within a single domain

For one side, if the network scale is large enough, with many MAs, scalability of the Controller may become an issue [I-D.ooki-lmap-internet-measurement-system]. It would be a simple and scalable manner to construct an effective LMAP system by dividing the huge number of MAs into groups, and assign a Controller separately to manager each subset of MAs. The size of the MA groups are dependent on the number of MAs that a single Controller can manage at a time during the real deployment.

On the other hand, even the network scale is small, if there are many heterogeneous network devices as functioning MAs, the corresponding LMAP protocols/interface may be diverse. For example, browser built-in MAs can be conveniently implemented as HTTP clients, the CPE devices usually support TR.069 as their management protocol and network devices residing in the core network generally support and

runs SNMP protocol by default. In other words, different Controllers speaking different LMAP protocols may be needed to respectively manage different groups of MAs in the real deployment.

If a measurement task involves MAs that belong to different groups, collaboration among corresponding Controllers is needed for instructing the MAs with the task configuration and report collection.

4.2.2 measurements for multi-domain ISP networks

For a large ISP, it is common practice to divide its global network into several autonomous domains, each operated and managed by a regional branch. It is therefore, very likely that separate LMAP systems would be deployed into these autonomous domains, resulting in a call for collaborative measurement scenarios even within the same ISP's network.

Take the case in China for instance, there are multiple nationwide ISP networks. Within these ISPs, relatively independent local branches, separated by physical territorial scope such as the province, operate their local network which has an autonomous domain or multiple autonomous domains. Each Provincial branch can deploy its own LMAP system to monitor its local network states.

4.3 Use-cases for the ICP

4.3.1 QoE-oriented performance enhancement

New applications or updated applications with newly-added functions/features are being pushed to the end user every day, with an increasing requirement for constant performance optimization based on realistic network utilization resultant from application dynamics. It is important to understand the practical performance and impact of various network segments (e.g. access network, transit network and Internet) on the end-to-end traffic path. For the design, experimental and operational phases of a new feature/technology introduction to an application is also of great importance. However, it is expensive and non-economic for each ICP to build its own dedicated LMAP system into various ISPs' networks.

At the same time, with the transition of ISPs' mindset from subscriber-centered charging for network access to ICP-centered

charging, ISPs are motivated to offer assistance to ICPs' exploration for better QoE through more efficient usage of network resources provisioned under the guidance of real-time performance measurements and optimization to accommodate application dynamics.

With ISPs' cooperation, various network segments are no longer hidden behind the black box to end-to-end performance measurements. By combining inputs from both its own end-based LMAP system with ISPs' measurement data, it is possible for an ICP to identify the bottleneck of service provision and develop corresponding enhancement via better guided technology introduction to the application as well as more targeted SLA negotiation with ISPs.

4.3.2 Trouble-shooting initiated by end consumers

With the growing influence of broadband access nowadays, more and more traditional ICPs are extending to the market of home gateways, as a result of the popularity of intelligent TVs and intelligent STBs. The services of end users in their home network are probably controlled by ICPs which may collaborate with the broadband access service providers to guarantee users the promised QoE. When malfunctions influencing user QoE occur in these types of services, it is necessary to have a mechanism with which the diagnostic measurement can be launched from the user side and identify the faulty party.

Generally the home gateway (such as a home WLAN router) is the border between the ISP network and the home network. The ISP network includes the access network, MAN and WAN. The home network includes home gateway, TV, STB, etc.

For a broadband access user who buys a third-party home gateway device, the typical service access path is shown in Figure 2. The home network between home gateway and UE is private and is not controlled by any ISP. However, the user may want to measure the link quality between the UE and the home gateway, the UE and the access ISP, or the UE to the ICP, separately. Thus in this scenario, it is difficult to deploy a single LMAP system which completely covers the whole path for accurate end-to-end QoE measurements and assists fault identification.

UE <=> home net <=> home GW <=> access ISP <=> transit ISP <=> Internet <=> ICP

Figure 2 Cross-Domain data traffic from home network to ICP

5 Derived Requirements

To make the requirements more clear, the following terms are defined:

LMAP domain: One LMAP domain is equal to one LMAP system specified in [i.d-ietf-lmap-framework], where all the MAs are controlled by a single controller.

This section presents derived requirements for LMAP protocols to enable the above collaborative use-cases across multiple LMAP domains. In particular:

- * Current LMAP architecture MUST be extended to allow the MAs of a LMAP domain to accept the legal external measurement tasks initiated outside of the LMAP domain.
- * When carrying out the outside measurement tasks, an LMAP domain MUST be able to coordinate the relevant controllers, MAs, and collectors of other LMAP domains for status updating or dynamical control.
- * Current LMAP architecture MUST be extended to have a mechanism to gather and aggregate the measurement results from participating LMAP domains.
- * An LMAP domain MUST be able to authenticate and authorize the measurement requests from outside of the LMAP domain.
- * The extended mechanisms required above SHOULD NOT affect the current LMAP mechanisms in [i.d-ietf-lmap-framework]. If changes have to be made, they MUST be kept as small as possible.

6 Extension Discussions

In general, there are two basic approaches to extend the existing LMAP framework for the above requirements: the first is to add another layer of MA management and report collection for the additional information exchange; the other is to extend the existing controller/reporter's function and make one of the relevant controller/reporter to take the responsibility of collaborative task instruction/data aggregation.

6.1 Adding Another Layer of Management/Aggregation

In particular, two entities for the general coordination of cross-organization interactions for collaborative LMAP tasks are introduced: the Initiator and the Reporter, for cross-domain measurement task assignment and result aggregation, respectively. Three protocols for interactions for the newly-introduced entities

and existing LMAP entities are discussed too.

6.1.1 Initiator-Controller exchange for task instruction

The globally trusted and verifiable Initiator instructs each participating LMAP Controller with corresponding Measurement Tasks to be performed within the LMAP system, indicating the corresponding Reporter, to whom the results of the Measurement Tasks are to be submitted. A globally unified identifier may be required for each collaborative Measurement Task.

6.1.2 Reporter-Collector exchange for data aggregation

A Collector from each participating LMAP system interacts with the corresponding Reporter to report local measurement results.

6.1.3 Initiator-Reporter exchange for output instruction

The Initiator also notifies the Reporter with instructions on how to create the final measurement report (e.g. data aggregation methods to be used) as well as the identities of the participating Controllers.

6.2 Extension over Existing Management/Aggregation Layer

Another straightforward manner of extending the current LMAP framework to support collaborative measurements from multiple domains is to break the assumption that "any MA can only be controlled by a single Controller", and allow the MA within an LMAP domain to carry on the instructions from another Controller outside the domain, and/or report the measurement results to another outside Collector.

Note that it is expected that such collaborative measurement instructions are not meant to change the ownership of the participating MA to its home LMAP domain.

As long as there is not conflict of interest or competition of local resources at the MA, the outside measurement tasks (from an outside Controller outside the local LMAP domain) as well as all the inside measurement tasks (from the inside Controller in the local LMAP domain) can be carried on simultaneously.

Otherwise, the MA may refer to static priority policies (e.g. the inside tasks have the top priority, etc.) or report to its local

Controller/a third party for conflict resolution and task adaptation.

7 Security Considerations

The security threats elaborated in [I-D.ietf-lmap-use-cases] also apply to collaborative LMAP scenarios.

It is assumed that the security issues within a participating LMAP system can be addressed by its local security mechanisms, as specified in [I-D.ietf-lmap-framework], and out of scope of this document.

Each participating LMAP system may have its own consideration and policy regarding its local network and/or subscriber private information. In performing collaborative task, it is still possible for a Collector to enforce local protection schemes, e.g. filtering algorithms, onto local measurement data before submission to the Reporter, hence providing protection to sensitive information for both the subscriber and the network operator.

It is important for a participating LMAP system to be able to authenticate the Initiator/outside-controller and the Reporter/outside-collector for a given collaborative Measurement Task, provide differentiated service provision according to its local policies (e.g. flexible authorization based on the Initiator's identity, the type of Measurement Task, Measurement Method, frequency, etc.), and protect itself from service abuse of malicious Initiators or information leakage to malicious Reporters.

A task/data verification scheme is needed for the Reporter to exclude un-authorized or non-intended Collectors from tampering the measurement report or blocking the Reporter/outside-collector from proper functioning with corrupted/forged/replayed local reports.

8 IANA Considerations

There is no IANA action in this document.

9 Acknowledgements

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Authors' Addresses

Lingli Deng
China Mobile

Email: denglingli@chinamobile.com

Rachel Huang
Huawei

Email: rachel.huang@huawei.com

Shihui Duan
China Academy of Telecommunication Research of MIIT

Email: duanshihui@catr.cn