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A Reference Path and Measurement Points for LMAP
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Abstract

This document defines a reference path for Large-scale Measurement of Broadband Access Performance (LMAP) and measurement points for commonly used performance metrics. The methods for measurement point location may be applicable to similar measurement projects using the extensions described here.

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1. Introduction

This document defines a reference path for Large-scale Measurement of Broadband Access Performance (LMAP) or similar measurement projects. The series of IP Performance Metrics (IPPM) RFCs have developed terms that are generally useful for path description (section 5 of [RFC2330]). There are a limited number of additional terms needing definition here, and they will be defined in this memo.

The reference path is usually needed when attempting to communicate precisely about the components that comprise the path, often in terms of their number (hops) and geographic location. This memo takes the path definition further, by establishing a set of measurement points along the path and ascribing a unique designation to each point. This topic has been previously developed in section 5.1 of [RFC3432], and as part of the updated framework for composition and aggregation, section 4 of [RFC5835] (which may also figure in the LMAP work

effort). Section 4.1 of [RFC5835] defines the term "measurement point".

Measurement points and the paths they cover are often described in general terms, like "end-to-end", "user-to-user", or "access". These terms alone are insufficient for scientific method: What is an end? Where is a user located? Is the home network included?

The motivation for this memo is to provide an unambiguous framework to describe measurement coverage, or scope of the reference path. This is an essential part of the meta-data to describe measurement results. Measurements conducted over different path scopes are not a valid basis for performance comparisons.

2. Purpose and Scope

The scope of this memo is to define a reference path for LMAP activities with sufficient level of detail to determine the location of different measurement points along a path without ambiguity.

The connection between the reference path and specific network technologies (with differing underlying architectures) is within the scope of this method, and examples are provided. Both wired and wireless technologies are in-scope.

The purpose is to create an efficient way to describe the location of the measurement point(s) used to conduct a particular measurement so that the measurement result will adequately described in terms of scope or coverage. This should serve many measurement uses, including:

diagnostic where the same metric may be measured over many different path scopes

comparison where the same metric may be measured on equivalent portions of different network infrastructures

3. Terms and Definitions

This section defines key terms and concepts for the purposes of this memo.

3.1. Reference Path

A reference path is a serial combination of routers, switches, links, radios, and processing elements that comprise all the network elements traversed by each packet between the source and destination hosts. The reference path is intended to be equally applicable to

all networking technologies, therefore the components are generically defined, but their functions should have a clear counterpart or be obviously omitted in any network technology.

3.2. Subscriber

An entity (associated with one or more users) that is engaged in a subscription with a service provider. The subscriber is allowed to subscribe and un-subscribe services, and to register a user or a list of users authorized to enjoy these services. [Q1741] Both the subscriber and service provider are allowed to set the limits relative to the use that associated users make of subscribed services.

3.3. Dedicated Component (Links or Nodes)

All resources of a Dedicated component (typically a link or node on the Reference Path) are allocated to serving the traffic of an individual Subscriber. Resources include transmission time-slots, queue space, processing for encapsulation and address/port translation, and others. A Dedicated component can affect the performance of the Reference Path, or the performance of any sub-path where the component is involved.

3.4. Shared Component (Links or Nodes)

A component on the Reference Path is designated a Shared component when the traffic associated with multiple Subscribers is served by common resources.

3.5. Resource Transition Point

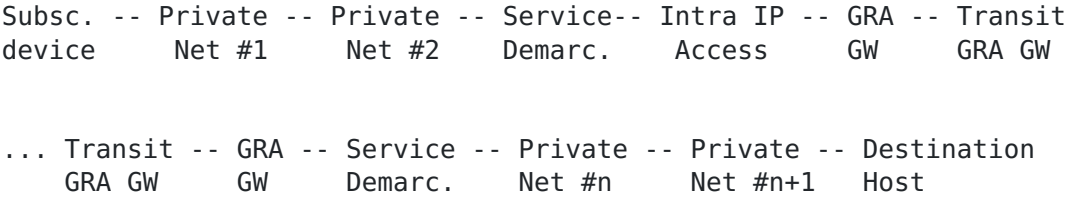
A point between Dedicated and Shared components on a Reference Path that may be a point of significance, and is identified as a transition between two types of resources.

3.6. Managed and Un-Managed Sub-paths

Service providers are responsible for the portion of the path they manage. However, most paths involve a sub-path which is beyond the management of the subscriber's service provider. This means that private networks, wireless networks using unlicensed frequencies, and the networks of other service are designated as un-managed sub-paths. The Service demarcation point always divides managed and un-managed sub-paths.

4. Reference Path

This section defines a reference path for Internet communication.



The following are descriptions of reference path components that may not be clear from their name alone.

- Subsc. (Subscriber) device - This is a host that normally originates and terminates communications conducted over the IP packet transfer service.

- Private Net #x - This is a network of devices owned and operated by the Internet Service Subscriber. In some configurations, one or more private networks and the device that provides the Service Demarcation point are collapsed in a single device (and ownership may shift to the service provider), and this should be noted as part of the path description.

- Service Demarcation point - This is the point where service managed by the serivce provider begins (or ends), and varies by technology. For example, this point is usually defined as the Ethernet interface on a residential gateway or modem where the scope of a packet transfer service begins and ends. In the case of a WiFi Service, this would be an Air Interface within the intended service boundary (e.g., walls of the coffee shop). The Demarcation point may be within an integrated endpoint using an Air Interface (e.g., LTE UE). Ownership may not affect the demarcation point; a Subscriber may own all equipment on their premises, but it is likely that the service provider will certify such equipment for connection to their network, or a third-party will certify standards compliance.

- Intra IP Access - This is the first point in the access architecture beyond the Service Demarc. where a globally routable IP address is exposed and used for routing. In architectures that use tunneling, this point may be equivalent to the GRA GW. This point could also collapse to the device providing the Service

Demarc., in principle. Only one Intra IP Access point is shown, but they can be identified in any access network.

- GRA GW - the point of interconnection between a Service Provider's administrative domain and the rest of the Internet, where routing will depend on the GRAs in the IP header.

- Transit GRA GW - If one or more networks intervene between the Service Provider's access networks of the Subscriber and of the Destination Host, then such networks are designated "transit" and are bounded by two Transit GRA GW.

Use of multiple IP address families in the measurement path must be noted, as the conversions between IPv4 and IPv6 certainly influence the visibility of a GRA for each family.

In the case that a private address space is used throughout an access architecture, then the Service Demarc. and the Intra IP Access points must use the same address space and be separated by the shared and dedicated access link infrastructure, such that a test between these points produces a useful assessment of access performance.

5. Measurement Points

A key aspect of measurement points, beyond the definition in section 4.1 of [RFC5835], is that the innermost IP header and higher layer information must be accessible through some means. This is essential to measure IP metrics. There may be tunnels and/or other layers which encapsulate the innermost IP header, even adding another IP header of their own.

In general, measurement points cannot always be located exactly where desired. However, the definition in [RFC5835] and the discussion in section 5.1 of [RFC3432] indicate that allowances can be made: for example, it is nearly ideal when there are deterministic errors that can be quantified between desired and actual measurement point.

The Figure below illustrates the assignment of measurement points to selected components of the reference path.

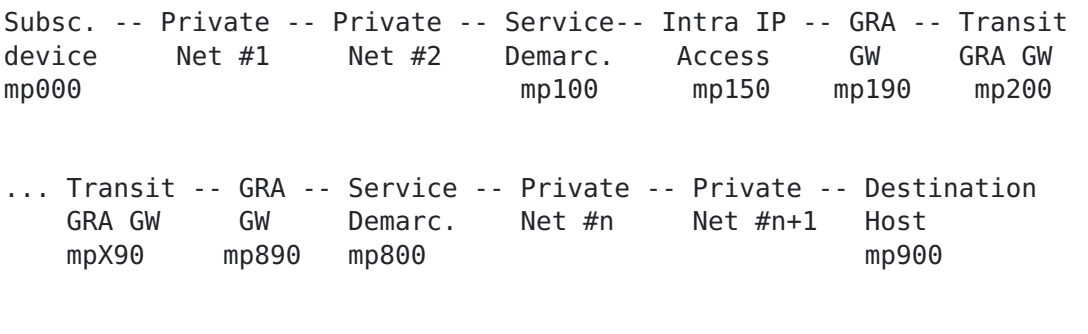


Figure 1

When communicating the results of measurements using the measurement point designations described here, the measuring organization SHOULD supply a diagram similar to Figure 1 (and the technology-specific examples that follow), and MUST supply it when additional measurement point numbers have been defined and used, with sufficient detail to identify measurement locations in the path. Organizations with similar technologies and architectures are encouraged to coordinate on local numbering and diagrams, when possible.

The measurement point numbering system, mpXnn, has two independent parts:

1. The X in mpXnn indicates the network number. The network with the Subscriber's device is network 0. The network of a different organization (administrative or ownership domains) SHOULD be assigned a different number. Each successive network number SHOULD be one greater than the previous network's number. Two circumstances make it necessary to designate X=9 in the Destination Host's network and X=8 for the Service Provider network at the Destination:

   A. The number of Transit networks is unknown.

   B. The number of Transit networks varies over time.

2. The nn in mpXnn indicates the measurement point and is locally-assigned by network X. The following conventions are suggested:

   A. 00 SHOULD be used for a measurement point at the Subscriber's device and at the Service Demarcation point or GW nearest to the Subscriber's device for Transit Networks.

B. 90 SHOULD be used for a measurement point at the GW of a network (opposite from the Subscriber's device or Service Demarc.).

C. In most networks, measurement point numbers SHOULD monotonically increase from point nearest the Subscriber's device to the opposite network boundary on the path (see below).

D. When a Detination host is part of the path, 00 SHOULD be used for a measurement point at the Destination host and at the the Destination's Service Demarcation point. Measurement point numbers SHOULD monotonically increase from point nearest the Destination's host to the opposite network boundary on the path ONLY in these networks. This directional numbering reversal allows consistent 00 designation for end hosts and Service Demarcs.

E. 50 MAY be used for an intermediate measurement point of significance, such as a Network Address Translator (NAT).

F. 20 MAY be used for a traffic aggregation point such as a DSLAM within a network.

G. Any other measurement points SHOULD be assigned unused integers between 01 and 99. The assignment SHOULD be stable for at least the duration of a particular measurement study, and SHOULD avoid numbers that have been assigned to other locations within network X (unless the assignment is considered sufficiently stale). Sub-networks or domains within a network are useful locations for measurement points.

In order to define the measurement points and the scope of measurements without ambiguity, the operator of the measurement system SHOULD indicate on a diagram (similar to those in this document): the reference path, the numbers (mpXnn) of the measurement points, and the definition of any measurement point other than 00 and 90 (with sufficient detail to clearly define its location).

If the number of intermediate networks (between the source and destination) is not known or is unstable, then this SHOULD be indicated on the diagram and results from measurement points within those networks need to be treated with caution.

Notes:

o Some use the terminology "on-net" and "off-net" when referring to the Subscriber's Internet Service Provider (ISP) measurement

coverage. With respect to the reference path, tests between mp100 and mp190 are "on-net".

- Widely deployed broadband Internet access measurements have used pass-through devices[SK] (at the subscriber's location) directly connected to the service demarcation point: this would be located at mp100.

- The networking technology must be indicated for the measurement points used, especially the interface standard and configured speed (because the measurement connectivity itself can be a limiting factor for the results).

- If it can be shown that a link connecting to a measurement point has reliably deterministic performance or negligible impairments, then the remote end of the connecting link is an equivalent point for some methods of measurement (To Be Specified Elsewhere). In any case, the presence of a link and claimed equivalent measurement point must be reported.

- Some access network architectures may have an additional traffic aggregation device between mp100 and mp150. Use of a measurement point at this location would require a local number and diagram.

- A Carrier Grade NAT (CGN) deployed in the Service Provider's access network would be positioned between mp100 and mp190, and the egress side of the CGN may be designated mp150. mp150 is generally an intermediate measurement point in the same address space as mp190.

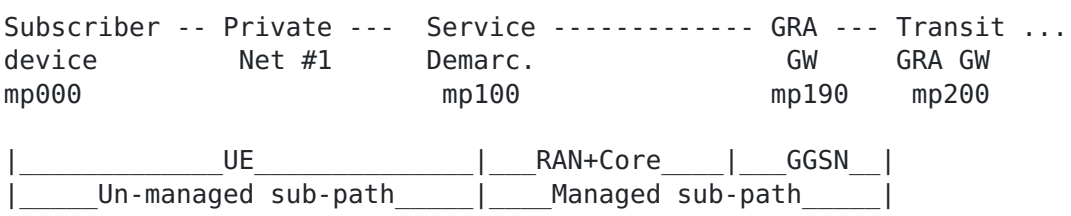
- In the case that private address space is used in an access architecture, then mp100 may need to use the same address space as its "on-net" measurement point counterpart, so that a test between these points produces a useful assessment of network performance. Tests between mp000 and mp100 could use a different private address space, and when the globally-routable side of a CGN is at mp150, then the private address side of the CGN could be designated mp149 for tests with mp100.

- Measurement points at Transit GRA GWs are numbered mpX00 and mpX90, where X is the lowest positive integer not already used in the path. The GW of first transit network is shown, with point mp200 and the last transit network GW with mpX90.

6. Translation Between Reference Path and Various Technologies

This section and those that follow are intended to provide a more exact mapping between particular network technologies and the reference path.

We provide an example for 3G Cellular access below.



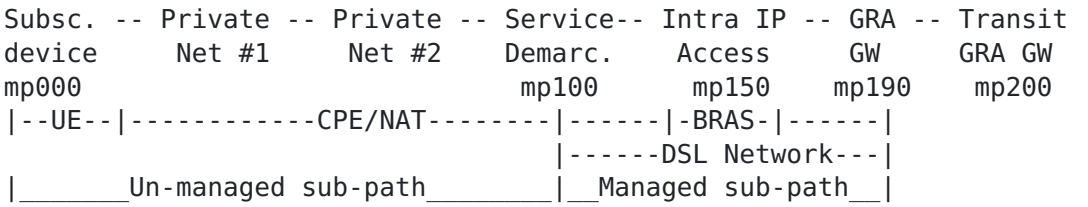
GRA = Globally Routable Address, GW = Gateway, UE = User Equipment, RAN = Radio Access Network, GGSN = Gateway GPRS Support Node.

We next provide a few examples of DSL access. Consider first the case where:

- The Customer Premises Equipment (CPE) has a NAT device that is configured with a public IP address.
- The CPE is a home router that has also an incorporated a WiFi access point and this is the only networking device in the home network, all endpoints attach directly to the CPE though the WiFi access.

We believe this is a fairly common configuration in some parts of the world and fairly simple as well.

This case would map into the defined reference measurement points as follows:



GRA = Globally Routable Address, GW = Gateway, BRAS = Broadband Remote Acess Server

Consider next the case where:

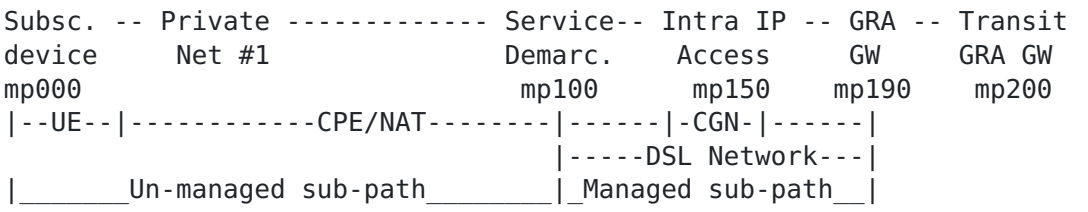
- The Customer Premises Equipment (CPE) is a NAT device that is configured with a private IP address.

- There is a Carrier Grade NAT (CGN) located deep into the Access ISP network.

- The CPE is a home router that has also an incorporated a WiFi access point and this is the only networking device in the home network, all endpoints attach directly to the CPE though the WiFi access.

We believe this is becoming a fairly common configuration in some parts of the world.

This case would map into the defined reference measurement points as follows:



GRA = Globally Routable Address, GW = Gateway

7. Example Resource Transition

This section gives an example of Shared and Dedicated portions with the reference path. This example shows two Resource Transition Points.

Consider the case where:

- The CPE is wired Residential GW and modem (Private Net#2) connected to a WiFi access point (Private Net#1). The Subscriber device (UE) attaches to the CPE though the WiFi access.

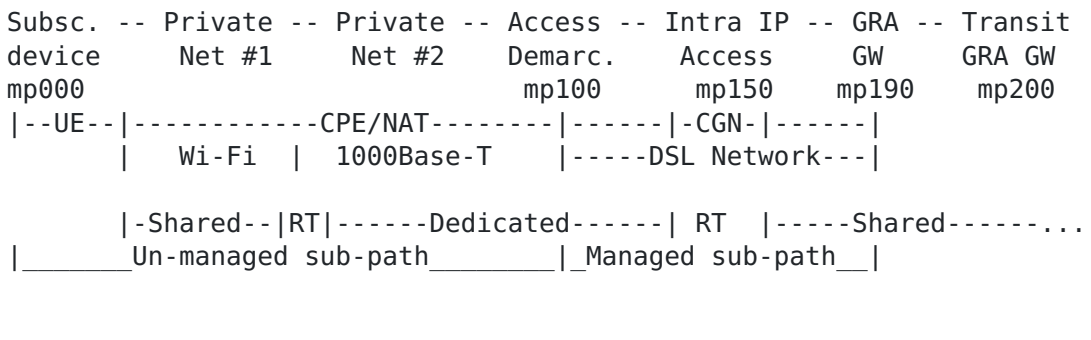
- The Wi-Fi subnetwork (Private Net#1) shares unlicensed radio channel resources with other W-Fi access networks (and potentially other sources of interference), thus this is a Shared portion of the path.

- The wired subnetwork (Private Net#2) and a portion of the Service Provider's Network are Dedicated Resources (for a single Subscriber), thus there is a Resource Transition Point between (Private Net#1) and (Private Net#2).

- o Subscriber traffic shares common resources with other subscribers upon reaching the Carrier Grade NAT (CGN), thus there is a Resource Transition Point and further network components are designated as Shared Resources.

We believe this is a fairly common configuration in parts of the world.

This case would map into the defined reference measurement points as follows:



GRA = Globally Routable Address, GW = Gateway, RT = Resource Transition Point

8. Security considerations

Specification of a Reference Path and identification of measurement points on the path represent agreements among interested parties, and they present no threat to the readers of this memo or to the Internet itself.

When considering privacy of those involved in measurement or those whose traffic is measured, there is sensitive information communicated to recipients of the network diagrams illustrating paths and measurement points described above. We refer the reader to the privacy considerations described in the Large Scale Measurement of Broadband Performance (LMAP) Framework [I-D.ietf-lmap-framework], which covers active and passive measurement techniques and supporting material on measurement context.

9. IANA Considerations

This memo makes no requests for IANA consideration.

10. Acknowledgements

Thanks to Matt Mathis, Charles Cook, Dan Romascanu, and Lingli Deng for review and comments.

11. References

11.1. Normative References

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11.2. Informative References

[I-D.ietf-lmap-framework] Eardley, P., Morton, A., Bagnulo, M., Burbridge, T., Aitken, P., and A. Akhter, "A framework for large-scale measurement platforms (LMAP)", draft-ietf-lmap-framework-05 (work in progress), May 2014.

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[Q1741] Q.1741.7, , "IMT-2000 references to Release 9 of GSM-evolved UMTS core network", http://www.itu.int/rec/T-REC-Q.1741.7/en, November 2011.

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