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Rate Measurement Test Protocol Problem Statement  
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## Abstract

This memo presents an access rate-measurement problem statement for test protocols to measure IP Performance Metrics. The rate measurement scenario has wide-spread attention of Internet access subscribers and seemingly all industry players, including regulators. Key test protocol aspects require the ability to control packet size on the tested path and enable asymmetrical packet size testing in a controller-responder architecture.

## Requirements Language

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](#)].

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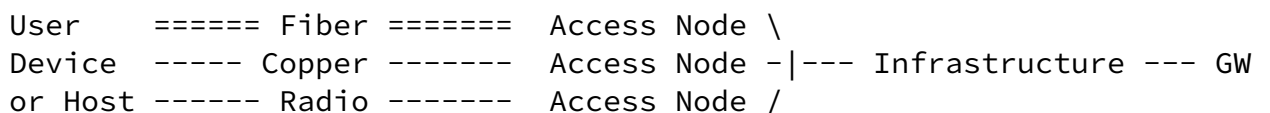
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[1.](#) Introduction

There are many possible rate measurement scenarios. This memo describes one rate measurement problem and presents a rate-measurement problem statement for test protocols to measure IP Performance Metrics (IPPM).

When selecting a form of access to the Internet, subscribers are interested in the performance characteristics of the various alternatives. Standardized measurements can be a basis for comparison between these alternatives. There is an underlying need to coordinate measurements that support such comparisons, and test control protocols to fulfill this need. The figure below depicts some typical measurement points of access networks.



The access-rate scenario or use case has received wide-spread attention of Internet access subscribers and seemingly all Internet industry players, including regulators. This problem is being approached with many different measurement methods.

## 2. Purpose and Scope

The scope and purpose of this memo is to define the measurement problem statement for test protocols conducting access rate measurement on production networks. Relevant test protocols include [\[RFC4656\]](#) and [\[RFC5357\]](#), but the problem is stated in a general way so that it can be addressed by any existing test protocol, such as [\[RFC6812\]](#).

This memo discusses possibilities for methods of measurement, but does not specify exact methods which would normally be part of the solution, not the problem.

We are interested in access measurement scenarios with the following characteristics:

- o The Access portion of the network is the focus of this problem statement. The user typically subscribes to a service with bi-directional access partly described by rates in bits per second. The rates may be expressed as raw capacity or restricted capacity as described in [\[RFC6703\]](#). These are the quantities that must be measured according to one or more standard metrics, and for which measurement methods must also be agreed as a part of the solution.
- o Referring to the reference path defined in [\[I-D.morton-ippm-lmap-path\]](#), possible measurement points include a Subscriber's host, the access service demarcation point, Intra IP access where a globally routable address is present, or the gateway between the measured access network and other networks.

Subsc. -- Private -- Private -- Access -- Intra IP -- GRA -- Transit

device      Net #1      Net #2      Demarc.      Access      GW      GRA GW

GRA = Globally Routable Address, GW = Gateway

- o Rates at some links near the edge of the provider's network can often be several orders of magnitude less links in than aggregation and core portions of the network.
- o Asymmetrical access rates on ingress and egress are prevalent.

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- o Extremely large scale of access services requires low complexity devices participating at the user end of the path.

This problem statement assumes that the most-likely bottleneck device or link is adjacent to the remote (user-end) measurement device, or is within one or two router/switch hops of the remote measurement device.

Other use cases for rate measurement involve situations where the packet switching and transport facilities are leased by one operator from another and the link capacity available cannot be directly determined (e.g., from device interface utilization). These scenarios could include mobile backhaul, Ethernet Service access networks, and/or extensions of layer 2 or layer 3 networks. The results of rate measurements in such cases could be employed to select alternate routing, investigate whether capacity meets some previous agreement, and/or adapt the rate of traffic sources if a capacity bottleneck is found via the rate measurement. In the case of aggregated leased networks, available capacity may also be asymmetric. In these cases, the tester is assumed to have a sender and receiver location under their control. We refer to this scenario below as the aggregated leased network case.

Support of active measurement methods will be addressed here, consistent with the IPPM working group's traditional charter. Active measurements require synthetic traffic dedicated to testing, and do not make measurements on user traffic.

As noted in [[RFC2330](#)] the actual traffic handling may influence the

rate measurement results for some forms of access, as it may differ between user and test traffic if the test traffic has different characteristics, primarily in terms of the packets themselves (see [section 13 of \[RFC2330\]](#) for the considerations on packet type, or Type-P).

There are several aspects of Type-P where user traffic may be examined and selected for special treatment that may affect transmission rates. Without being exhaustive, the possibilities include:

- o Packet length
- o IP addresses
- o Transport protocol (where TCP packets may be routed differently from UDP)
- o Transport Protocol port numbers

This issue requires further discussion when specific solutions/methods of measurement are proposed, but for this problem statement it is sufficient to identify the problem and indicate that the solution may require an extremely close emulation of user traffic, in terms of one or more factors above.

Although the user may have multiple instances of network access available to them, the primary problem scope is to measure one form of access at a time. It is plausible that a solution for the single access problem will be applicable to simultaneous measurement of multiple access instances, but treatment of this scenario is beyond the current scope this document.

A key consideration is whether active measurements will be conducted with user traffic present (In-Service testing), or not present (Out-of-Service testing), such as during pre-service testing or maintenance that interrupts service temporarily. Out-of-Service testing includes activities described as "service commissioning", "service activation", and "planned maintenance". Opportunistic In-Service testing when there is no user traffic present throughout the test interval is essentially equivalent to Out-of-Service testing. Both In-Service and Out-of-Service testing are within the scope of

this problem.

It is a non-goal to solve the measurement protocol specification problem in this memo.

It is a non-goal to standardize methods of measurement in this memo. However, the problem statement will mandate support for one or more categories of rate measurement methods in the test protocol and adequate control features for the methods in the control protocol (assuming the control and test protocols are separate).

### 3. Active Rate Measurement

This section lists features of active measurement methods needed to measure access rates in production networks.

Coordination between source and destination devices through control messages and other basic capabilities described in the methods of IPPM RFCs [[RFC2679](#)][RFC2680], and assumed for test protocols such as [[RFC5357](#)] and [[RFC4656](#)], are taken as given.

Most forms of active testing intrude on user performance to some degree. One key tenet of IPPM methods is to minimize test traffic effects on user traffic in the production network. [Section 5 of \[RFC2680\]](#) lists the problems with high measurement traffic rates, and the most relevant for rate measurement is the tendency for

measurement traffic to skew the results, followed by the possibility of introducing congestion on the access link. In-Service testing MUST respect these traffic constraints. Obviously, categories of rate measurement methods that use less active test traffic than others with similar accuracy are preferred for In-Service testing.

On the other hand, Out-of-Service tests where the test path shares no links with In-Service user traffic have none of the congestion or skew concerns, but these tests must address other practical matters such as conducting measurements within a reasonable time from the tester's point of view. Out-of-Service tests where some part of the test path is shared with In-Service traffic MUST respect the In-Service constraints.

The **\*\*intended metrics to be measured\*\*** have strong influence over

the categories of measurement methods required. For example, using the terminology of [[RFC5136](#)], it may be possible to measure a Path Capacity Metric while In-Service if the level of background (user) traffic can be assessed and included in the reported result.

The measurement \*architecture\* MAY be either of one-way (e.g., [[RFC4656](#)]) or two-way (e.g., [[RFC5357](#)]), but the scale and complexity aspects of end-user or aggregated access measurement clearly favor two-way (with low-complexity user-end device and round-trip results collection, as found in [[RFC5357](#)]). However, the asymmetric rates of many access services mean that the measurement system MUST be able to evaluate performance in each direction of transmission. In the two-way architecture, it is expected that both end devices MUST include the ability to launch test streams and collect the results of measurements in both (one-way) directions of transmission (this requirement is consistent with previous protocol specifications, and it is not a unique problem for rate measurements).

The following paragraphs describe features for the roles of test packet SENDER, RECEIVER, and results REPORTER.

SENDER:

Generate streams of test packets with various characteristics as desired (see [Section 4](#)). The SENDER may be located at the user end of the access path, or may be located elsewhere in the production network, such as at one end of an aggregated leased network segment.

RECEIVER:

Collect streams of test packets with various characteristics (as described above), and make the measurements necessary to support rate measurement at the receiving end of an access or aggregated leased network segment.

REPORTER:

Use information from test packets and local processes to measure

delivered packet rates, and prepare results in the required format.

#### 4. Measurement Method Categories

The design of rate measurement methods can be divided into two phases: test stream design and measurement (SENDER and RECEIVER), and a follow-up phase for analysis of the measurement to produce results (REPORTER). The measurement protocol that addresses this problem MUST only serve the test stream generation and measurement functions.

For the purposes of this problem statement, we categorize the many possibilities for rate measurement stream generation as follows;

1. Packet pairs, with fixed intra-pair packet spacing and fixed or random time intervals between pairs in a test stream.
2. Multiple streams of packet pairs, with a range of intra-pair spacing and inter-pair intervals.
3. One or more packet ensembles in a test stream, using a fixed ensemble size in packets and one or more fixed intra-ensemble packet spacings (including zero spacing, meaning that back-to-back burst ensembles and constant rate ensembles fall in this category).
4. One or more packet chirps, where intra-packet spacing typically decreases between adjacent packets in the same chirp and each pair of packets represents a rate for testing purposes.

For all categories, the test protocol MUST support:

- a. Variable payload lengths among packet streams
- b. Variable length (in packets) among packet streams or ensembles
- c. Variable IP header markings among packet streams
- d. Choice of UDP transport and variable port numbers, OR, choice of TCP transport and variable port numbers for two-way architectures only, OR BOTH.

- e. Variable number of packets-pairs, ensembles, or streams used in a



test session

The items above are additional variables that the test protocol MUST be able to identify and control. The ability to revise these variables during an established test session is OPTIONAL, as multiple test sessions could serve the same purpose.

The test protocol SHALL support test packet ensemble generation (category 3), as this appears to minimize the demands on measurement accuracy. Other stream generation categories are OPTIONAL.

For measurement systems employing TCP Transport protocol, the ability to generate specific stream characteristics requires a sender with the ability to establish and prime the connection such that the desired stream characteristics are allowed. See Mathis' work in progress for more background [[I-D.mathis-ippm-model-based-metrics](#)].

>>>>>

The general requirement statements needed to describe an "open-loop" TCP sender require some additional discussion. It may be necessary to defer specification of the details required to configure and control a TCP SENDER for future work.

>>>>>

It may also be useful to specify a control for Bulk Transfer Capacity measurement with fully-specified TCP senders and receivers, as envisioned in [[RFC3148](#)], but this would be a brute-force assessment which does not follow the conservative tenets of IPPM measurement [[RFC2330](#)].

>>>>>

Measurements for each UDP test packet transferred between SENDER and RECEIVER MUST be compliant with the singleton measurement methods described in IPPM RFCs [[RFC2679](#)][[RFC2680](#)] (these could be listed later, if desired). The time-stamp information or loss/arrival status for each packet MUST be available for communication to the protocol entity that collects results.

## 5. Test Protocol Control & Generation Requirements

Essentially, the test protocol MUST support the measurement features described in the sections above. This requires:

1. Communicating all test variables to the Sender and Receiver

2. Results collection in a one-way architecture
3. Remote device control for both one-way and two-way architectures
4. Asymmetric packet size and/or pseudo-one-way test capability in a two-way measurement architecture (along with symmetric packet size tests in common use)

The ability to control packet size on the tested path and enable asymmetrical packet size testing in a two-way architecture are REQUIRED. This allows both the conventional symmetric packet size testing and asymmetrical packet size testing to be employed to solve various aspects of rate measurement: real-time communications often have symmetrical streams, while file transfers have highly asymmetrical streams in the data and acknowledgement traffic directions.

The test protocol SHOULD enable measurement of the [[RFC5136](#)] Capacity metric, either Out-of-Service, In-Service, or both. Other [[RFC5136](#)] metrics are OPTIONAL.

## 6. Security Considerations

The security considerations that apply to any active measurement of live networks are relevant here as well. See [[RFC4656](#)] and [[RFC5357](#)].

There may be a serious issue if a proprietary Service Level Agreement involved with the access network segment provider were somehow leaked in the process of rate measurement. To address this, test protocols SHOULD NOT convey this information in a way that could be discovered by unauthorized parties.

## 7. IANA Considerations

This memo makes no requests of IANA.

## 8. Acknowledgements

Dave McDysan provided comments and text for the aggregated leased use case. Yaakov Stein suggested many considerations to address, including the In-Service vs. Out-of-Service distinction and its implication on test traffic limits and protocols. Bill Cervený, Marcelo Bagnulo, and Kostas Pentikousis have contributed insightful, clarifying comments that made this a better draft.

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