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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Interpreting ITU-T Y.1540 maximum IP-layer capacity measurements

ITU-T Y-series Recommendations – Supplement 60

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Supplement 60 to ITU-T Y-series Recommendations

Interpreting ITU-T Y.1540 maximum IP-layer capacity measurements

Summary

Supplement 60 to ITU-T Y-series Recommendations provides information on interpreting ITU-T Y.1540 maximum IP-layer capacity measurements, described in Annex A and Annex B of that Recommendation.

This Supplement provides useful information for those who measure various technologies. Much has been learnt as part of the extensive testing campaigns so far, and there is more to learn. Therefore, this Supplement may be updated frequently, and readers are encouraged to ensure that they have the most recent version.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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Supplement 60 to ITU-T Y-series Recommendations

Interpreting ITU-T Y.1540 maximum IP-layer capacity measurements

1 Scope

This Supplement provides information on methods to interpret [ITU-T Y.1540] maximum IP-layer capacity measurements, and the auxiliary measurements of fundamental IP packet performance parameters collected simultaneously. Specifically:

– Guidance on the use of Figure A.1of [ITU-T Y.1540] – Flowchart for offered load adjustment as part of a search algorithm, versus Figure B.1 of [ITU-T Y.1540] – Flowchart for offered load adjustment, Type B Search Algorithm,

– Examples where maximum IP-layer capacity measurement results need to be carefully interpreted,

– Example of an [ITU-T Y.1540] Annex B table of sending rates.

A future revision of this Supplement will additionally provide:

– Guidance for comparing different forms of measurements with the normative methods of [ITU-T Y.1540];

– Test results of notes relevant to the post-publication of [ITU-T Y.1540];

– Other methods.

2 References

[ITU-T Y.1540] Recommendation ITU-T Y.1540 (2019), *Internet protocol data communication service – IP packet transfer and availability performance parameters*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

IP Internet Protocol

5 Conventions

None.

6 Recommendation for use of Annex B (Type B) search algorithm

This clause provides guidance on the use of Figure A.1 of [ITU-T Y.1540] – Flowchart for offered load adjustment as part of a search algorithm, versus Figure B.1of [ITU-T Y.1540] – Flowchart for offered load adjustment, Type B Search Algorithm .

When considering the two normative flowcharts for the two algorithms, it is observed that they have some common features. As explained in Annex B of [ITU-T Y.1540]:

– There are three main paths through the flowchart: when feedback indicates measured impairments are absent, or when impairments are first measured and some congestion may be present but sending rate change is deferred, or when measured impairments are confirmed by repeated measurement feedback.

Figure 6-1 illustrates these three paths. Evaluation is triggered by the arrival of a new status report, and the result is the change (or retention) of the current sending rate, depending on the measurements.

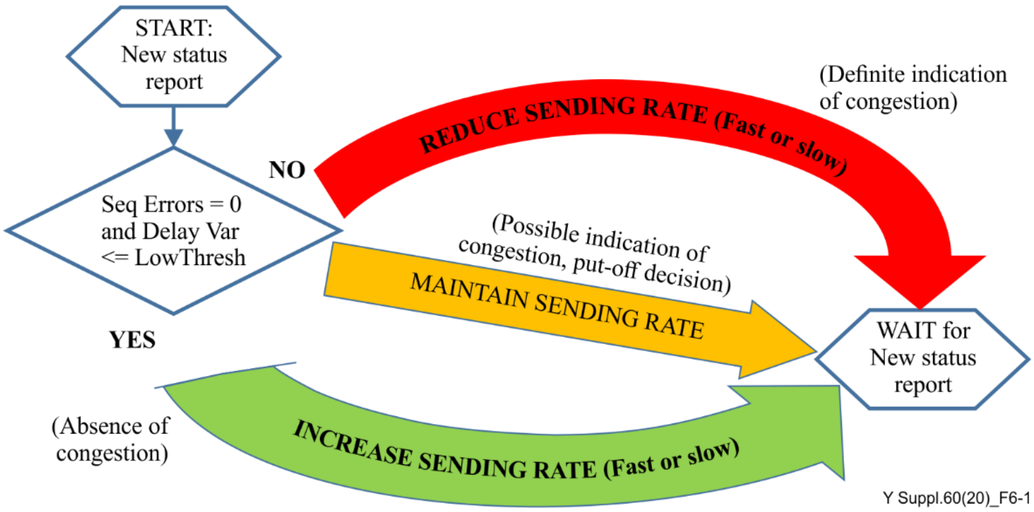

Figure 6-1 – Three main paths through the search algorithm flowcharts

The Annex B (Type B) search adds two supplementary capabilities to the evaluation of measurements and control of the sending rate not available in the Annex A algorithm:

1 Initial fast increase of the sending rate from the default starting rate of 500 kbit/s. This saves time when testing access capacities that are in the gigabit range, but allows the same parameter settings to be used over a wide range of IP-layer capacities (cellular rates of 1 Gbit/s may take some time before they become available for many regions).

2 Initial fast decrease of the sending rate when congestion is confirmed, to minimize overshoot and continue a less-aggressive search in the range where measurements indicate that a capacity limit may have been reached.

These features may reduce the time required for measurements of maximum IP-layer capacity and the auxiliary metrics such as loss and round-trip time, as illustrated in Figure 6-2, which are depictions of time at the receiver.

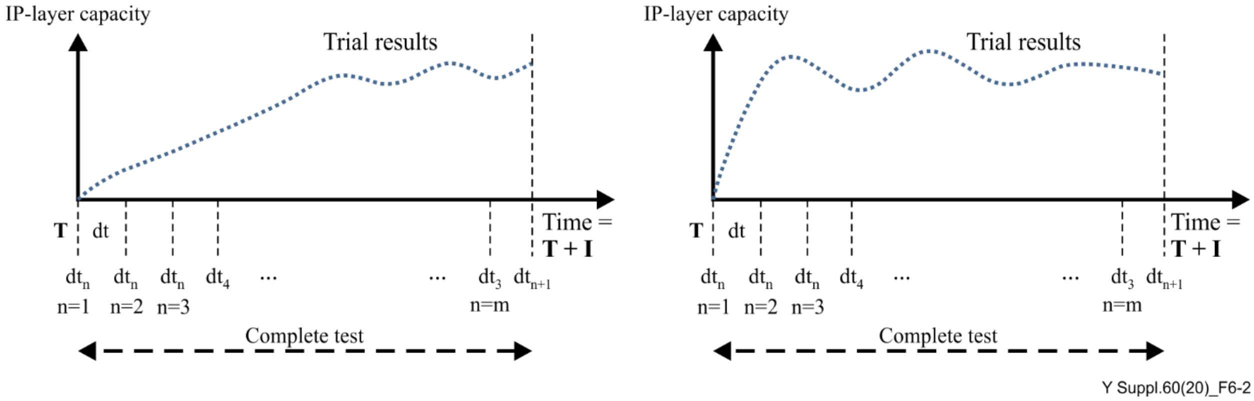

Figure 6-2 – Illustration of relative speed of Annex A (left) and Annex B (right) algorithm

Also, the parameters of the Annex B (Type B) algorithm allow for more control over the behaviour of the search and its performance in specific circumstances. Finally, it is possible to set the parameters of the Annex B (Type B) algorithm so that the resulting search follows the algorithm in Annex A.

It is for these reasons that Figure B.1 of [ITU-T Y.1540] – Flowchart for offered load adjustment, Type B Search Algorithm (Annex B), is preferred, and should be implemented by measurement systems measuring maximum IP-layer capacity and the auxiliary metrics.

The concluding statements of Annex B concern the topic of testing with parallel connections:

– The current view is that each connection would have its own feedback channel, calculation of measurements and flowchart, and a report of the aggregate results over all connections.

This means that results of each connection for number of bits transferred during *dt* would be computed separately (as well as other metrics), and possibly reported separately for each connection, if requested.

7 Example of results requiring careful interpretation

This clause provides examples where the maximum IP-layer capacity measurement results need to be carefully interpreted.

7.1 Measurement results indicating a bi-modal distribution of capacities

Some forms of Internet access include a mode of operation where the early packets of a new connection are allowed to flow at a higher rate than the subsequent packets. The definition of "early" is not defined, it could be time in seconds or total bytes observed, but the purpose is to give the appearance of better service to the user's application. For example, a web page might load faster, or a stream might reach its initial buffering point more quickly. Figure 7-1 illustrates how this might be observed in IP-layer capacity measurements.

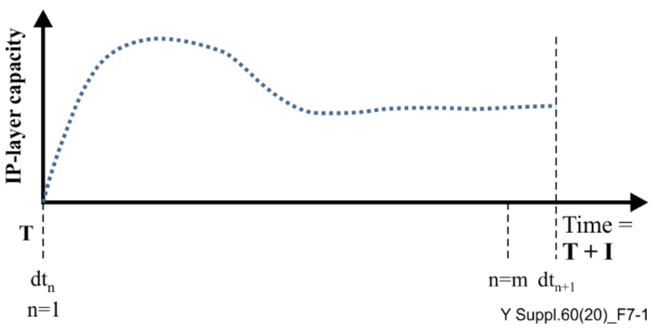

Figure 7-1 – Illustration of multiple modes of operation encountered in measurement

This network behaviour was more prevalent when Internet access speeds were limited by both shaping and technology, and sometimes called "turbo mode". However, this mode of operation has been observed in US measurements during 2019 (Matt Mathis, private communication). Some applications continue to derive potential performance benefits, so the measurement analyst should be prepared to recognize such cases. The sustained IP-layer capacity will only be observed after the conditions of the "turbo mode" are satisfied, and the shaping parameters return to normal.

The distinguishing feature of "turbo mode" is its reliable and repeatable measurement after a sufficiently long interval where traffic is idle (also, the user may know that they have such a feature enabled, but features and capacities are often added or dropped without the user comprehending the notification in some form).

It is strongly recommended that when the bi-modal behaviour described above is encountered, that the two modes are characterized independently as an enhanced mode and a sustained mode. Near-continuous testing allows more time to measure the IP-layer capacity of the sustained mode.

It is also notable that some conditions may cause an individual measurement to possess bi-modal or multi-modal characteristics. For example, switches between more/less complicated modulation constellations, cellular modem technologies (3G, LTE, 5G) modes, or severe weather intervals could cause short-time modes to appear. However, such conditions are unlikely to repeat exactly in subsequent measurements.

7.2 Measurement results where packet losses occur independently from sending rate

There are conditions which might be encountered during measurement where packet losses may occur independently from send rate. Such cases include testing where there is a significant volume of competing traffic from many users, or when the production network performance exhibits a sufficient, yet small amount of packet loss that the search algorithms would misinterpret as congestion. The presence of background packet loss will slow the initial advance of the search algorithm, possibly resulting in a measurement result where the true capacity has not been found during the configured test duration. Figure 7-2 illustrates the effect on the progress of either Annex A or Annex B search algorithms.

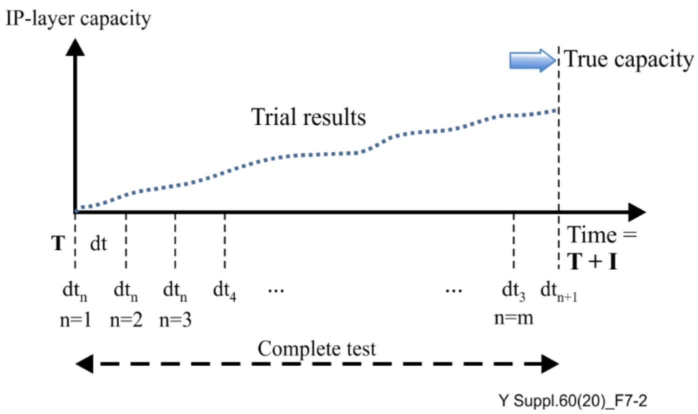

Figure 7-2 – Illustration of effect of background packet loss encountered in measurement

One factor which distinguishes the background loss condition from normal capacity limits in the measurements is the lack of delay variation observed as reported in the frequent status messages.

There are three potential mitigations when encountering background loss:

1 Test for longer durations: Search progress is being made in Figure 7-2 but doubling the test interval may be helpful to achieve the accurate measurement of capacity in this example.

2 Start the test at a higher initial sending rate, anticipating the shallow slope of the search.

3 Revise the Annex B (Type B) parameters from the default values, to make the search more aggressive in the presence of packet loss, while retaining the same sensitivity to delay variation. One setting to change is SlowAdjThresh, currently default at 2. Tests have shown that setting the SlowAdjThresh to a very high value avoids both the slow mode of rate increases and the fast recovery branch of the rate decrease branch of the flowchart. As mentioned earlier, this is a key advantage of the Annex B (Type B) algorithm.

In summary, there are several mitigations for background packet loss effect on accuracy, and a clear way to distinguish the condition: the lack of delay variation present in measurements.

8 Example of an ITU-T Y.1540 Annex B table of sending rates

When describing the system that conforms to Annex B of [ITU-T Y.1540], the text describes a pre-defined table:

– A table of transmit rates, which are the number of packets sent during each time interval (corresponding to bits per second and a specified protocol layer) and packet sizes. The table has ascending values for offered load rates, between the minimum and maximum supported load rates, inclusive.

Table 8-1 below begins with the configured initial rate and contains a representation of a table that has been used (with reduced detail).

8.1 Example table

An example sending rates table is given in Table 8-1 . This table can be used with both Annex A and Annex B. Note that this table directly computes the bit rate from packet counts, as this was considered more efficient.

Table 8-1 – Example table for Annex B

Index No.	Other components, such as sending interval, payload size(s), spacing parameters, back-to-back (burst) lengths, etc.	Mbit/s (L3/IP)
0		0.50
1		1.00
2		2.00
3		3.00
4		4.00
…		…
997		997.00
998		998.00
999		999.00
1000		1000.00
…		…

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