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Abstract:

The document defines the needs for the correlation of the results of the measures among different collectors and probes both in the network and application scope, as a main input to WP4.

Keywords:

Collect, Consolidation, Correlation.

Revision History

The following table describes the main changes done in the document since its creation.

Revision	Date	Description	Author (Organization)
v0.1	5/12/2002	Document creation	Yann Adam (FT)
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v2.1	20/06/2003	Typos	Emile Stephan (FT)
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Executive Summary

Metrics are the basic elements that permit to have information from somewhere about something. In order to get relevant information, metrics are specific, dedicated to a special task, for example a round trip time or the time taken to download a file.

Some of them can be used as it is, but sometimes we would like to have more information because:

- There is a lack of measurement somewhere in the network.
- The metric is not detailed enough (for instance the download time of a file is abnormally high but we don't know if it is due to the network or the application server).
- The metric used does not look like the traffic we want to measure (for example, getting a round-trip time with a PING when we want to qualify a VoIP flow).

The consolidation is a response to these issues:

- Get the understanding of an (abnormal) event when not all the information is available.
- Get the relevant information extracted from numerous metrics collected.

Table of Contents

Table of Figures

1. INTRODUCTION

This section defines the procedures to access the measurement results establishing the correspondence and relationship of all the points of measure the measurements and the tools used specifying the type of measure performed (passive or active).

1.1 General Description

Consolidation can take on many different meanings. In order to avoid ambiguity, we use the word consolidation to mean the following:

- Considering a set of metrics coming from different means of measurements, how can the metrics be combined in such a way as to provide more global measurement?

Metrics themselves can come from many different sources, such as network probes, applications, and even service related metrics. These metrics, when taken individually, can certainly be valuable in reaching conclusions regarding the performance of a network, an application, or a service. However, they become potentially even more valuable when combined to determine consolidated measurements and higher-level conclusions about performance.

The Figure 1-1 illustrates various types of metrics that can be found.

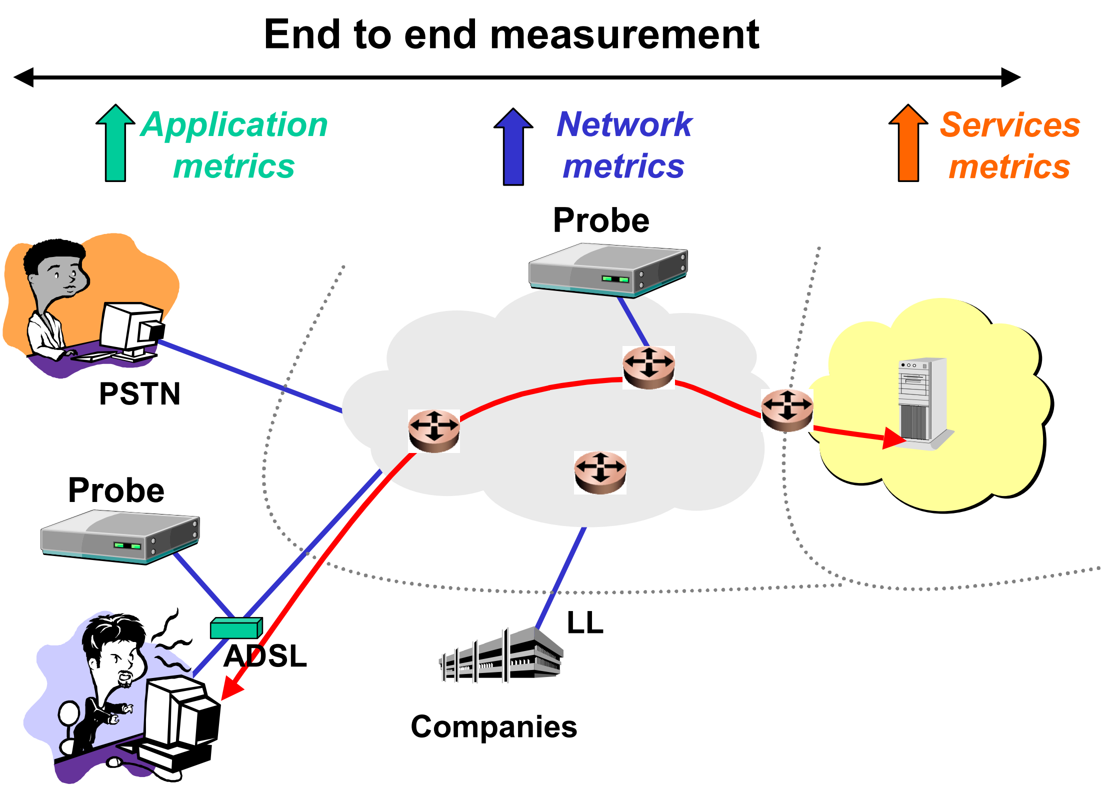

Figure 1-1: End-to-end Measurement

1.2 Stack Level Consolidation

The above figure illustrates different types of metrics.

- **Application metrics**: Metrics related to the application level. Examples are response time for an HTML page, response time for a mail recovery, response time for an FTP transfer, packet loss and discard, …
- **Network metrics**: Metrics related to the network level. Examples are one-way delay, packet loss, jitter, round-trip time, …
- **Service metrics**: Metrics related to the services applications. Examples are number of client connections, number of DNS requests, …

Some probes are dedicated to a specific level, whereas others have the ability to measure several levels. The goal of the stack level consolidation is to manage metrics coming from different levels in order to compute a multi-level metric. Note that a metric does not necessarily exist for each level.

1.3 Spatial Consolidation

By spatial composition, we mean a characteristic of some path metrics, in which the metric as applied to a (complete) path can also be defined for various sub-paths, and in which the appropriate A-frame concepts for the metric suggest useful relationships between the metric applied to these various sub-paths (including the complete path, the various cloud sub-paths of a given path digest, and even single routers along the path). Spatial consolidation therefore would be the aggregation of the various sub-path metrics.

Note that a metric does not inevitably exist for each node in the path that a flow might traverse.

1.4 Active/Passive Consolidation

Active measurements allow for the computation from a source IP address to a destination IP address such metrics as one-way delay, one-way packet loss, and other various metrics. These measures are normally obtained through the injection of test packets into the network. Passive measures allow for the “observance” of packets as they traverse various nodes in the network. The consolidation of these two types of metrics can be useful in the computation of end-to-end QoS measurement and management.

Note that both active and passive metrics may not be available for the entire path that is traversed by a particular IP flow.

1.5 QoS Modeling

Sometimes the information on a given metric is not enough to estimate the global quality of an end-to-end connection or of a sub-path. It is then necessary to cross the measurement results of this metric with the one of other metrics, so that a better understanding (i.e. modeling) of the global quality, as finally provided to the end user, can be reached.

Examples of such models are:

- For VoIP, the computation of a global quality score, using either an adaptation of the E-model (ITU-T G.107) or an aggregation on the P.800 MOS scale.

- The end-to-end one-way delay and packet loss rate of a communication are made of various contributions that can be derived from other metrics or information (type of coder, size and dynamics of de-jitter-buffers, etc.).

This approach can be applied to both active and passive types of measurements.

2. REQUIREMENTS FOR HOP-BY-HOP CONSOLIDATION

2.1 Quality of the Metrics Computed using a Concatenation of Spatial Metrics

2.1.1 Problem Presentation

There are various reasons why the measurement of spatial metrics is key to the network service provider:

- For locating delay consumption in an IP path.
- For locating the loss of packets on an IP path.
- For trajectory discovery.
- For troubleshooting the network.
- For designing and engineering the networks.
- For measuring the performance of a multicast network.
- For controlling the performance of the inter domain services.

This section examines the requirements for the consolidation of these hop-by-hop metrics, particularly in comparison to end-to-end measurements over a given path.

The notion of spatial metric consolidation is illustrated below.

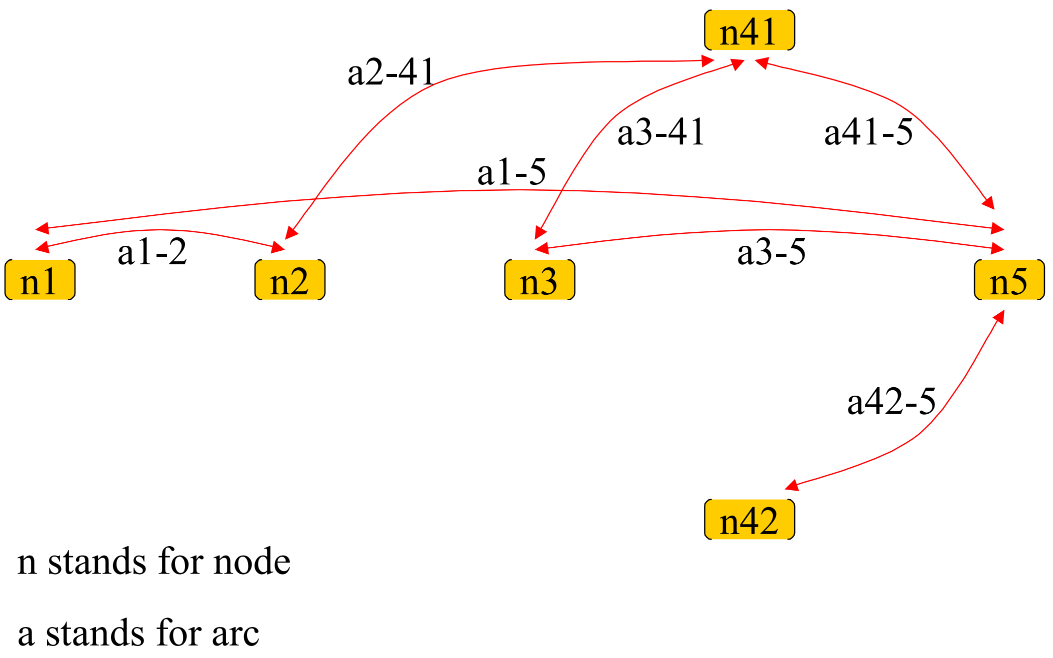

Figure 2-1: Spatial Consolidation

This figure shows 2 entities:

- **Nodes[N]**: A node is an equipment (either a equipment of the service infrastructure or a dedicated probe).
- **Arcs**: An arc is a path on which a measurement takes place.

2.1.2 Requirements for Spatial Metric Consolidation

It is required to synchronize the time of nodes involved in QoS measurement along an arc. This requirement concerns both intra and inter-domain environments, knowing that there is a higher risk not to have such synchronization configured in the inter-domain environment. In such situation, the nodes of each domain should be synchronized to the same public or shared NTP server or should be synchronize using GPS.

In inter-domain environment, the QoS measurements must be defined in cooperation and take into account the nature and features of the nodes involved in each domain. For example, a QoS measurement that is defined and work within a domain A, involving nodes from another domain B, could be ineffective due to a lack of support of this measurement from the nodes deployed in the domain B.

2.1.3 Constraints

The following constraints of the spatial consolidation are related both to the intra and inter-domain environments but the risk associated is higher in inter-domain:

- Topology: Administrative issues in inter-domain topology regarding access to configuration and alerts.
- Metric availability: Lack of control and visibility of the nodes deployed in the different domains involved in the QoS measurement.
- Measurement time: Coordination of the measurement time.
- Synchronization: Nodes involved in a QoS measurement along an arc must be synchronized in time.

3. Requirements for Consolidation of Active and Passive Measures Results

3.1 Combination of the Passive and Active Measure Result

3.1.1 Problem Presentation

The figure below illustrates the concept of the combination of passive and active measurements.

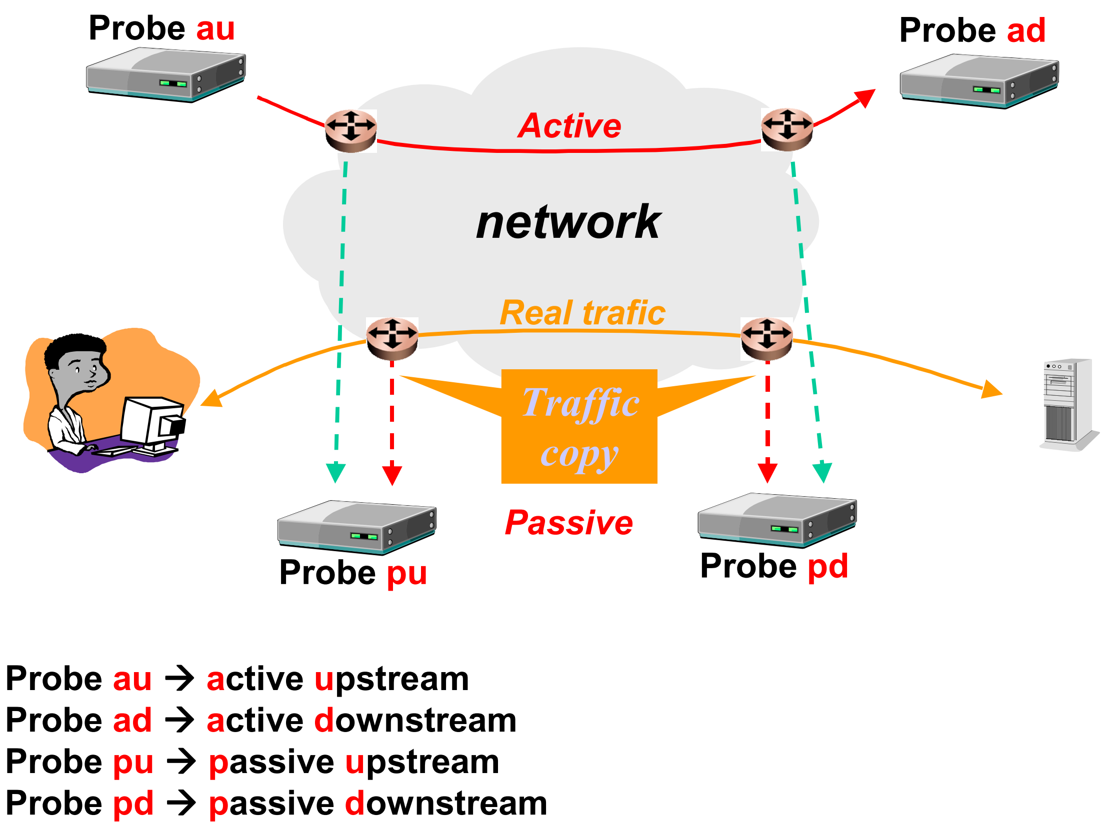

Figure 3-1: Passive and Active Measurement Combination

This figure clearly shows the 2 modes:

- **Active measurement:** The upstream probe generates traffic for the downstream probe.
- **Passive measurement:** The probes measure the real traffic.

A combination of these 2 modes would be an active measurement traffic being measured by a passive measurement system (green arrows on figure 3).

3.1.2 Requirements for Passive and Active Measurement Consolidation

The traffic measured in both active and passive measurements must follow similar paths or take into account this factor. The note spotted in 1.4 is also significant in this context: If the active and passive metrics are not available for the entire path, either the same path must be used for both measurements, or the difference must be taken into account.

The Active measurement traffic must be similar to the Traffic copied by the Passive node.

Exporting of the traffic copy achieved by the passive probe should have a limited impact on the measurement (through the impact on the performance of the router for example).

The probes and nodes involved in a measurement in both active and passive measurements must be synchronized in time. At least, the synchronization must be accurate separately for the active measurements (the probes are synchronized) and the passive measurements (nodes are synchronized). This requirement concerns both intra and inter-domain environments, knowing that there is a higher risk not to have such synchronization configured in the inter-domain environment. In such situation, the nodes of each domain should be synchronized to the same public or shared NTP server or make use of GPS antenna.

3.1.3 Constraints

Constraints of the active/passive consolidation in intra and inter-domain topology, based on the figure above:

- Topology: Validity of the paths followed by the IP flow for active and passive measurements, administrative issues in inter-domain topology.
- Metric availability: Lack of control and visibility of the nodes deployed in the different domains involved in the QoS measurement.
- Measurement time: The time when active and passive measurements are achieved must be the same in order to have IP flows meeting similar traffic proprieties along both paths, the constraint presents an higher risk in inter-domain topology.
- Synchronization: Nodes and probes involved in a QoS measurement along a path (active/passive) must be synchronized in time.

4. Combination of Network and Application Level Measures

4.1 Requirements for Combination of Network and Application Level Measures

4.1.1 Problem Presentation

The figure below illustrates the concept of the combination of network and application level measurement.

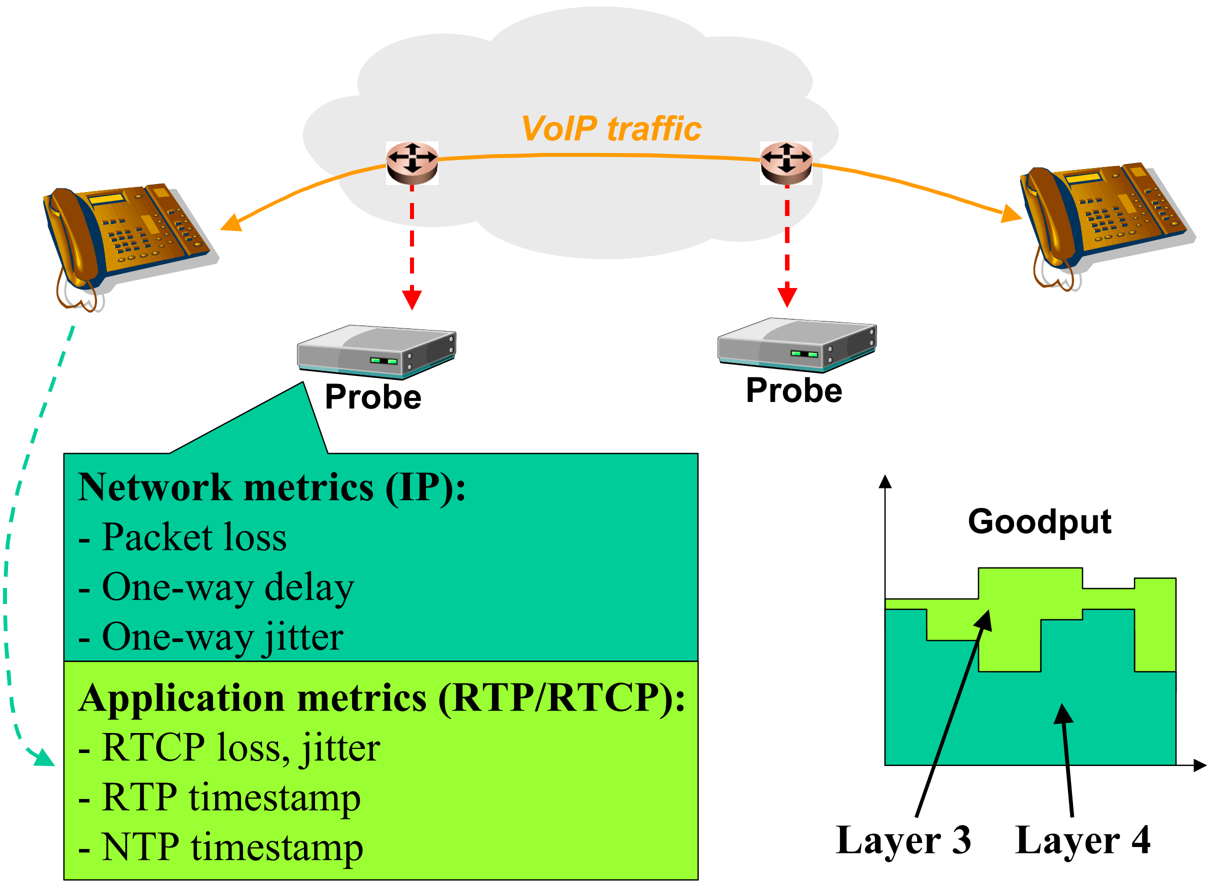

Figure 4-1: Network and Application Measurement Combination

This figure shows that the probes can provide metrics for several stack levels. In this example, the probes give layer 3 and layer 4 metrics.

The metrics can be collected on different probes/equipment, including the end points (for application metrics only, see the green arrow on Figure 4-1.

Some metrics are presented in several layers, for example the loss metric exists both at the network layer (in IPPM metrics for instance) and at application layer (in RTCP fields).

4.1.2 Requirements for Network and Application Level Consolidation

Layer issues:

- Availability of metrics in different protocol layers: When presenting a consolidated metric, it is mandatory that this metric be available in all protocol layers involved.
- The real protocol must be taken into account: For example when measuring a TCP packet loss, it is mandatory to have a real TCP flow and not only an IP flow with the TCP protocol number in its header.
- Well-known protocol stacks should be used in order to make the measurement relevant. For example, a metric involving the TCP stack should not use 'the-TCP-stack-of-my-lab-with-good-performances-without-slow-start-and-with-a-big-window-size.tar.gz' …
- When a multi-layer metric is computed, it is mandatory to make the computation on metrics coming from the same packets because the network and the host making the measurement may treat different packets differently.
- When a metric involves a session-type protocol, it is mandatory to distinguish the different sections of the session, for example the duration of the whole session, the time taken to establish the connection, the duration of the transfer, the time taken by the disconnection.

Time and synchronization issues:

- When the metric involves measurements in different places, it is mandatory that the measurement tools be synchronized.
- The time of the highest layer must be kept for a multi-layer metric: for example the time field of a metric involving both network and application layer must be filled with the application time. The reason is that upper layers induce their own computation time (OS, reassembly of the frame…).

4.1.3 Recommendations for Implementation

General recommendations:

- Design the architecture the most generic as possible regarding metric data structures and treatments. An example (which is not directly related to consolidation) is to use getaddrinfo() and getnameinfo() (both available for IPv4 and IPv6) instead of gethostbyname() which is available for IPv4 only.
- Use well-known, standardized references for the naming of the metrics when possible.

When metric names are the same for different levels (packet loss for instance), keep this name (they both represent a packet loss) but distinguish them with a layer/protocol/application attribute. For example, *IP_packet_loss* and *RTP_packet_loss*.

Consolidation recommendations:

- Consolidation must take care of encapsulation/packet headers when computing multi-layer metrics. For example, IPv4 and IPv6 headers lengths are not the same.

Metrics must be clearly documented: for instance the lost of one application packet does not mean that only one network layer packet was also loose. When the information is available it can be useful to indicate that the lost of this application layer packet is related to the lost of the N corresponding network packets.

5. SUMMARY AND CONCLUSIONS

The consolidation can take place in different areas, at different levels.

It is a complicated process because it deals with many different issues:

- Measurement points and measurement paths.
- Active and/or passive measurement methodologies.
- Application/network layers.

The recommendations show that the correlation must be taken into account all along the measurement process: Specification of the metrics, implementation of the applications, and placement of the probes, …

But this tricky work is important because its main goal is to provide the final user with the most relevant information, and avoid either to flood him with too many information or not to give him enough information.

Deploying a measurement system is (very) expensive, of course because of equipment investments but particularly on account of the exploitation costs. So, the motivation to do this deployment must be justified by the value-added of the measurement. One of these value-added is the consolidation.