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eSAM - Performance Assessment

The large-scale deployment of converged services over Ethernet / IP networks such as Voice, Video and Television requires a feasibility study that clearly identifies the levels of quality (QoS), as well as Bandwdth constraints and bottlenecks that could affect their normal use. The effectiveness of a teleapplication is a combination of multiple factors that include network architecture, and transmision media. It do also depends on resource management, serialization of traffic, congestion control and other factors. Therefore the introduction of a new application such as VoIP is never deterministic in terms of sustainability and quality.

In some respects the use of the right tools and a methodology allow the analysis of the capacity, and quality that affect your network. They really determine the success -or failure- in the implementation of new services. It is fundamental to identify those weaknesses of the telecom networks as the first decisition to improve new applications.

Figure 1 *ALBEDO Ether.Giga is a field tester for Ethernet equipped with all the features to install and maintain Ethernet infrastructures supporting legacy features such as BER and RFC2544 while new test such as eSAM Y.1564.*

1. SERVICE ACTIVATION

Ethernet service activation though eSAM defined in ITU-T 1564 has arisen as an alternative to RFC 2544 verification. Unlike the RFC 2544, eSAM is designed for Ethernet service activation from the beginning. The advantages of eSAM in front of RFC 2544 are summarized in the following points:

1. *Faster execution*: An standard eSAM test is made up of a short configuration test and a longer performance test. If the configuration test fails there is no need to execute the long performance test. The result is that network administrators have time to correct any configuration issue before having to wait for the complete test execution.
2. *FDV results*. Frame Delay Variation (FDV) is a key metric to evaluate network performance. FDV is very sensitive to congestion and other degradations that affect end-to-end network performance and it is therefore an essential parameter to measure.

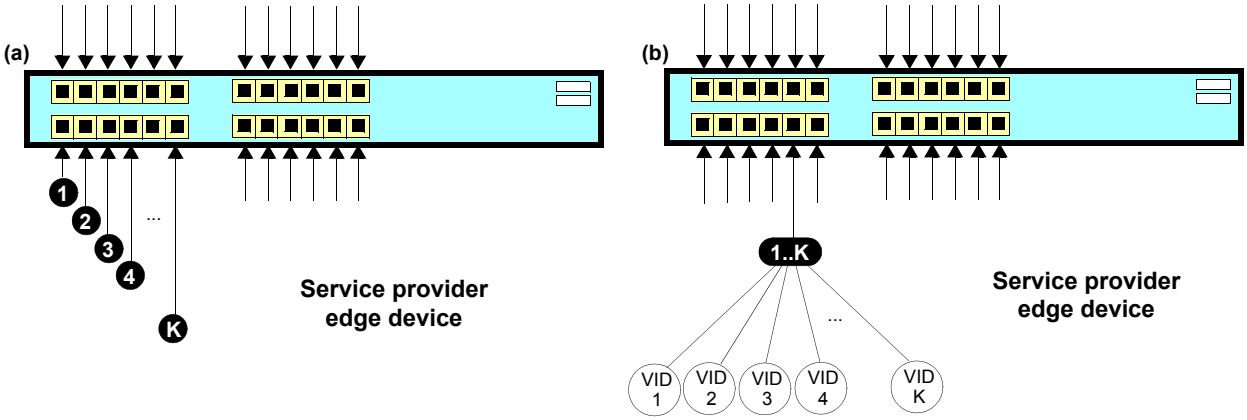

Figure 2 *(a) Port based Ethernet service, one service per port. (b) Ethernet service multiplexing based on service delimiting markers like the VLAN tag.*

3. *Compatible with multiservice environments*: Modern Ethernet services may be port based but service multiplexing in the same port by means some service delimiting tag is also very popular. The eSAM test has been designed to operate in environments using service multiplexing. In this case, all services are simultaneously tested and independent results are given for each of them.
4. *Supports color-aware traffic*: The eSAM test is compatible with color markers used by some service providers to enable the different performance levels in their applications. Color markers classify the network traffic in three sets: *green* traffic is transmitted within the delay and frame loss ratio limits guaranteed by the SLA agreement, *yellow* traffic is transmitted but the SLA agreement performance limits do not apply for it, and finally *red* traffic is discarded and not transmitted (red traffic is therefore never seen in the network). Common color markers used in practical applications are the DSCP (Layer 3) and the VLAN priority bits (Layer 2). The latter requires the subscriber frames to be encapsulated in VLAN tagged frames.

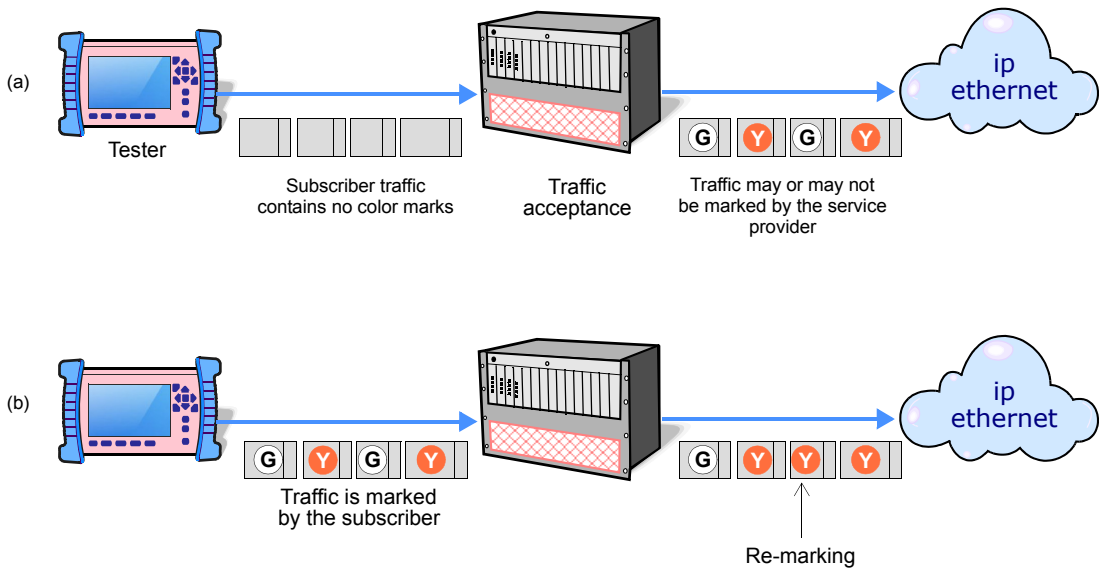

Figure 3 *(a) Non-color-aware service. It the service provider is wiling to implement different transmission priorities for this service, marking will have to be carried out by the access network by means some traffic classification algorithm. (b) In a color-aware service subscribers mark their own traffic from the beginning. The service provider may remark some traffic depending on the traffic acceptance algorithm.*

Bandwidth Profiles for Ethernet Services

To see how eSAM works it is essential to understand how Ethernet services are defined. Network operators have at their disposal the tools that enable them to define their services with great flexibility. The information rate associated with Ethernet service is not limited to the nominal speed of the access network interface. For example, certain operator way want to define a 2 Mbit/s service over an optical Gigabit Ethernet interface.

Performance in terms of delay, packet loss and other metrics is applied to traffic flows defined by their generation statistics or bandwidth profile. The mechanism used by service providers to make sure the ingress traffic has the correct bandwidth profile is admission control. Once the Ethernet access has been set up, the service provider performs admission control over the customer traffic at the user-network interface. Admission control for Ethernet services uses bandwidth profiles based on four parameters initially defined by the Metro Ethernet Forum (MEF):

- *Committed Information Rate (CIR)*: Rate up to which service frames are delivered as per the service performance objectives.
- *Committed Burst Size (CBS)*: Maximum number of bytes up to which service frames may be sent as per the service performance objectives without considering the CIR.
- *Excess Information Rate (EIR)*: Rate up to which service frames are still delivered but they are not subject to any performance objective.

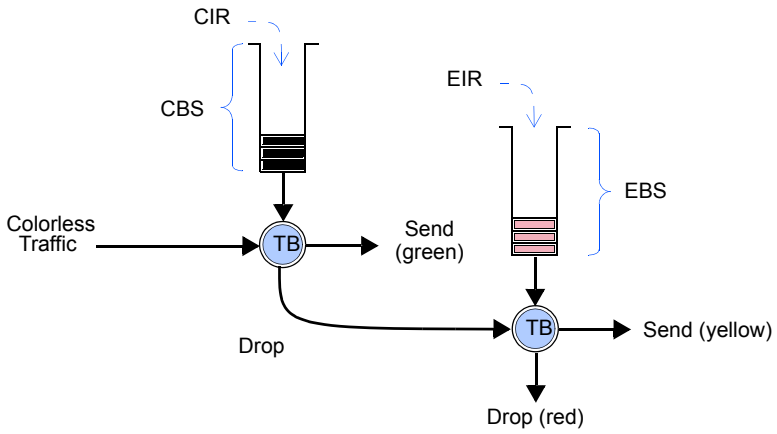

Figure 4 *Two-rate Three color marker (trTCM). policing algorithm.*

- *Excess Burst Size (EBS)*: The number of bytes up to which service frames are sent (without performance objectives), even if they are out of the EIR threshold.

The MEF specifies the RFC 2698 *Two-rate Three-Color Marker* (trTCM) as the admission control mechanism for carrier Ethernet services. The trTCM is obtained by chaining two simple token bucket policers. Tokens fill the main bucket until they reach the capacity given by the CBS parameter, at a rate given by the CIR parameter. The secondary bucket is filled with tokens with the EIR rate until they reach the capacity given by the EBS parameter.

The traffic that passes through the first bucket (green traffic) is delivered with the QoS agreed with the service provider, but any traffic that passes through the secondary bucket (yellow traffic) is re-classified and delivered as best-effort traffic, or it is given a low priority. Non-conforming traffic (red traffic) is dropped.

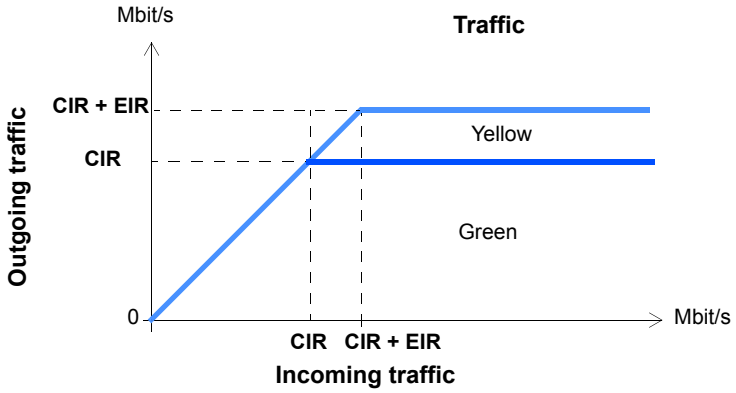

Figure 5 *The amount of traffic that crosses an admission control filter. Graphics represent steady states, traffic is usually allowed to be greater than the CIR and EIR for short periods of time. Traffic delivery is guaranteed if the rate is smaller than the CIR. Excess traffic (EIR traffic) is delivered as well, but it is marked as low priority and usually discarded first if congestion occurs.*

Figure 6 *CIR, EIR and policing test results as presented by Ether.Genius / Ether.Sync / Ether.Giga.*

Note than the best effort classical service can be obtained simply by setting the CIR parameter to zero. Moreover, service providers may allow their subscribers to add their color marks to the traffic they generate before the traffic admission algorithm is applied. This kind of pre-marking transfers more control on the application performance to the end user. However, admission control is necessary even in this case and frame remarking is done on non-conforming traffic anyway.

The basic purpose of eSAM is to check that green and yellow frames are transported with the required performance in terms of Frame Total Delay (FTD), Frame Delay Variation (FDV), Frame Loss Ratio (FLR) and availability. The existence of a policing algorithm like the trTCM means that testing the ability of the network to discard non-conforming traffic is another important requirement for eSAM. Transmission of green traffic is verified by the CIR test and the performance test, transmission of the yellow traffic is checked with the EIR test and red (discarded) traffic is measured by the policing test. Finally, the Information Rate (IR) is measured in all CIR, EIR and policing tests for all traffic classes to make sure that the information is preserved by the network when required to do so. More details about these specific tests are provided in the following sections.

Test Configuration

Like almost any test to be carried out by Ether.Genius / Ether.Sync / Ether.Giga, the way the equipment is configured depends on the particular network and service to be tested. Before running the test, there are several questions the user must answer:

- What kind of network is going to be tested? Configuration is different for IP networks and Ethernet networks. Note than a network may carry IP over Ethernet frames but it may still be more interesting to run an Ethernet test than an IP test.
- How is the test equipment going to be connected to the network? Configuration is not the same if there is a traffic reflector used to loop frames back to the analyser (two-way test) or if Port B is going to be used for analysis (one-way test).
- How many services are required to be measured in the same test? Is there any color marker used to classify the traffic? Which are the CIR / EIR values

Table 1
eSAM Configuration

Setting	*Description*
Color mode	Set this field to *On* if the traffic contains color labels. Color labels enable the network to supply differentiated services to selected traffic. These services consist in low delay paths, high priority frame scheduling or low packet loss probability. Set the *Color mode* to *Off* if you want to leave the service provider network to decide the priority of user traffic based on the result of a traffic acceptance algorithm (policer, shaper).
Color method	The color method configures which field in the test traffic implements the color mechanism. There are the following potential choices: • *DSCP*: Differentiated Services Code Point. It is 6-bit class of service label that accepts values between 0 and 63. DSCP makes sense as a color marker in routed networks and for this reason it is not available in *Ethernet endpoint mode*. • *C-VLAN priority*: 3-bit class of service field carried by the VLAN tag in IEEE 802.1Q frames or in the C-VLAN tag in IEEE 802.1ad and Q-in-Q frames. Using this field requires frames containing at least one VLAN tag. Color markers based on the C-VLAN priority field make sense only in switched networks for this reason it is not available in *IP Endpoint*. • *C-VID*: VLAN identifier assigned to tagged frames (IEEE 802.1Q) or C-VLAN identifier for double tagged frames (IEEE 802.1ad, Q-in-Q). The VID is commonly used in carrier Ethernet networks as a service discriminator. The Ether.Genius / Ether.Sync / Ether.Giga testers account for the possibility to use this field as a colour marker as well. It requires the tester to be configured in *Ethernet Endpoint* mode and an encapsulation with at least one VLAN tag. • *S-VLAN priority*: 3-bit class of service field carried by the S-VLAN tag in IEEE 802.1ad and Q-in-Q frames. Color markers based on the C-VLAN priority field make sense only in switched networks for this reason it is not available in *IP Endpoint* mode . • *S-VID*: VLAN identifier assigned S-VLAN tag in double tagged frames (IEEE 802.1ad, Q-in-Q). The VID is commonly used in carrier Ethernet networks as a service discriminator. The Ether.Genius / Ether.Sync / Ether.Giga testers account for the possibility to use this field as a colour marker as well. It requires the tester to be configured in *Ethernet Endpoint* mode and an IEEE 802.1ad / Q-in-Q encapsulation
Number of services	Defines the number of services to be simultaneously tested. The maximum number of services to be tested is eight (non-color-aware mode) or four (color-aware mode).
Number of steps	Number of different bit rates to be tested in the configuration CIR test. The test bit rates are equally distributed between 0 and CIR bit rates.
Step duration (s)	Duration of each iteration of the CIR test. If Number of steps is configured to 1, it is the duration of the CIR test. Any value between 1 and 60 seconds is accepted.
Policing test	Enable to execute the policing test as a part of the eSAM test suite or disable if you don't want to run the policing test. You may want to disable the policing test if you know that the network under test is not using any traffic admission algorithm and you don't want the configuration test to fail for this reason.
Performance test duration	Duration of the eSAM performance test. The performance test is executed once the configuration test has finished. For the performance test you can choose between one of the three duration presets (*15 min.*, *2 hours*, *24 hours*) or you can set your own test duration with a resolution of one second by setting this field to *User duration*. It is possible to use this field to disable the performance test. This is interesting if you want to check the network configuration but you don't need to know the performance.
User duration	Use this field to configure the eSAM performance test duration if you have set *Performance test duration* to *User duration*.
Service configuration	Displays a panel that enables the user to enter the CIR and EIR for each service to be tested. The service configuration panel also displays information about the Ether.Genius / Ether.Sync / Ether.Giga traffic flows assigned to each eSAM service. Two flows are required to test one color-aware service and one flow is necessary for each non-color-aware service.

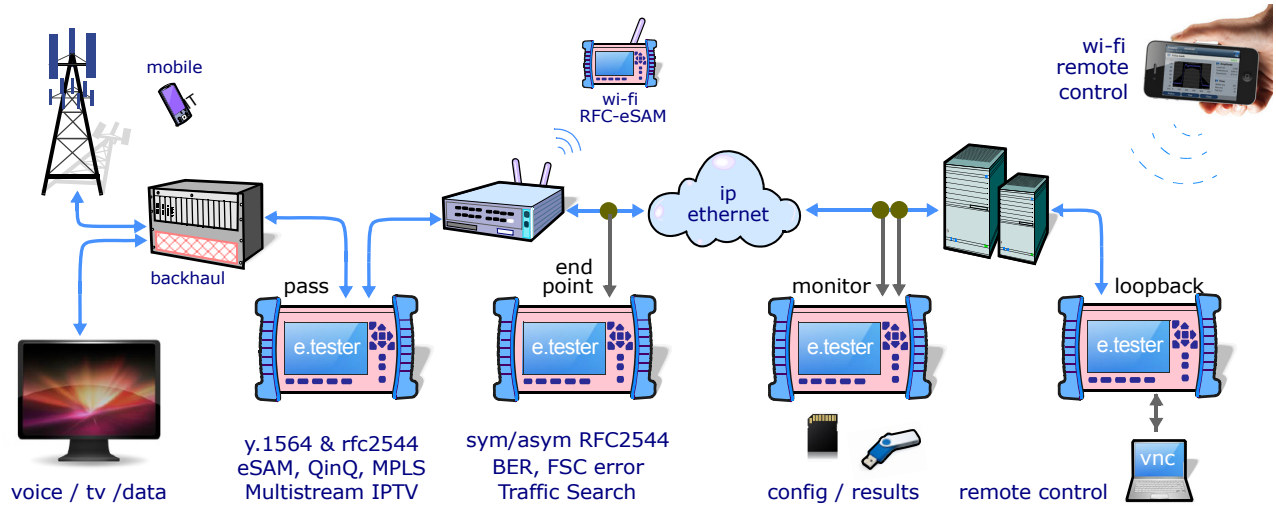

Figure 7 *ALBEDO Ether.Genius / Ether.Sync / Ether.Giga field testers in operation.*

for each service? Is there any policing mechanism for the Ethernet services configured in the network?

- What is the required performance for each service in terms of FTD, FDV, FLR and availability?
- In IP tests, what are the correct IP profiles to be used? IP addresses, network masks, gateways and DNS servers (if used) must be known before the test can be configured. Usually DHCP protocol makes easier configuration of IP profiles but DHCP may not be available in some networks.

Once all the details about test equipment connection and network / service configuration have been clarified is time to configure the test. To do that follow these steps:

1. Make sure that your tester is connected to the network. The physical layer must be up and working.
2. From the *Home* panel, go to *Test*,
   The test configuration panel is displayed.
3. Choose between *Ethernet endpoint* or *IP endpoint* with the *Mode* setting.
4. Depending on your test setup, configure *Test method* to *One-way (A > B)* or *Two-way (A > A)*.
5. Configure *Performance test* to *eSAM*.
6. Enter in the *eSAM* menu to configure the global ITU-T Y.1564 settings.
7. Configure the *Color mode* to *On* if the service provider allows pre-marking of Ethernet frames / IP datagrams or set it to *Off* otherwise.
8. If you have configured *Color mode* to *On*, set the *Color method* to *DSCP* (IP Endpoint mode), *C-VLAN priority*, *C-VID*, *S-VLAN priority* or *S-VID* (Ethernet Endpoint mode).
   Note: C-VLAN priority and C-VID color markers require VLAN, Q-in-Q or IEEE 802.1ad encapsulation. S-VLAN priority and S-VID color markers require

Q-in-Q or IEEE 802.1ad encapsulation

9. Set the number of services you want to test within the same test with the help of the *Number of services* control.
   Note: The maximum number of services is 4 if *Color mode* is *On* or 8 if *Color mode* has been configured to *Off*.
10. Configure the *CIR* and *EIR* parameters for each service to be tested from the *Service configuration* panel.
11. Enter the number of steps and duration of each step for the CIR test with the help of the *Number of steps* and *Step duration (s)* controls.
12. Enable the Policing test with *Policing test* if your network is using a traffic admission mechanism that limits the amount of accepted ingress traffic
13. Configure the duration of the eSAM performance test with the help of the *Performance test duration* and *User duration* controls.
14. Leave the *eSAM* configuration panel and from the *Test* menu select Performance objectives.
15. Select *eSAM* and enter the performance objectives in terms of the *FLR*, *FTD*, *FDV* and *Avail.* fields for each service you want to test.

Table 2
eSAM Performance Metrics

Result	*Description*
Load (Mbt/s)	Amount of test traffic offered to the network expressed in Mbit/s. This traffic is always larger or equal than the measured Information Rate (IR). Currently this parameter is displayed as a result only for the CIR configuration test. Traffic load for EIR and performance tests can be checked in the service configuration panel for eSAM tests. For policing tests, the load is always higher than the CIR + EIR in an amount than is computed automatically as specified in ITU-T Y.1564.
IR (Mbit/s)	Average Information Rate (IR) computed for the traffic currently being tested (green, yellow, aggregated,...) within the configured test period. Only test traffic is taken into account to measure the IR. The definition and application of the IR metric follows ITU-T Y.1564.
FLR	Ratio of the total amount of lost frames to the total transmitted frames from the beginning of the test. Definition of the FLR parameter follows ITU-T Y.1563.
FTD (ms)	Is the worst case (maximum) Frame Total Delay (FTD) found from the beginning of the eSAM configuration or performance test and expressed in milliseconds. The definition of *FTD (ms)* follows ITU-T Y.1563 and it is computed in the same way that the *FTD (maximum)* metric supplied by the Ether.Genius / Ether.Sync / Ether.Giga *SLA statistics*.
FDV (ms)	Is the worst case (maximum) Frame Delay Variation (FDV) found from the beginning of the eSAM configuration or performance test and expressed in millisecond. The definition of *FDV (ms)* follows RFC 3393 and RFC 1889 and it is computed in the same way that the *FDV (maximum)* metric supplied by the Ether.Genius / Ether.Sync / Ether.Giga *SLA statistics*.
Avail (%)	The Avail (%) constitutes an availability performance figure that informs about the percentage of time that the DUT / SUT has been not available for transmit / receive data during the eSAM performance test. This performance metric is computed as *100% - PEU(%)*. Where the PEU(%) is the Percent Ethernet service Unavailability defined in ITU-T Y.1563 and supplied by the Ether.Genius / Ether.Sync / Ether.Giga *SLA statistics*. This metric is computed for eSAM performance tests only. Configuration tests are considered too short to make any accurate availability result significant enough.

16. Configure the *Frame layer*in Port A for all your services. Parameters to be configured are source and destination MAC addresses, VLANs, frame size, etc.
    Note: To know the correspondence between the Ether.Genius / Ether.Sync / Ether.Giga flows and the eSAM services, check the *Service configuration* panel you have used to configure the CIR and EIR values for the test.
    Note: Test traffic corresponding to different services should not have exact configurations. Otherwise, the analyser (and the network) will fail to classify the traffic. A service delimiting field could be used for this purpose. It is common to use the VID but anything that makes traffic from different services different in some way is accepted by the tester.
    Note: If you are configuring colored traffic, the color makers (C-VLAN priority, C-VID, S-VLAN priority, S-VID) must have a different value for green and yellow traffic corresponding to the same service. The test will fail to start if this requirement is not met.
17. If you are working in *IP endpoint* mode, configure the *Local profile* and the *Network layer* for all your services. Parameters to be configured are IP addresses, DSCPs, etc.
    Note: Previous notes about flows / services, service delimiting tags and color markers are valid in *IP endpoint* as well but in this case the color marker to be used is the DSCP rather than VLAN priorities or VIDs.
18. Run the eSAM test with the help of the *RUN* fixed button.

CIR Configuration Test

The CIR Configuration test is the most basic eSAM test. Its purpose is to check the ability of the network to deliver frames at CIR rate within acceptable performance limits. This test consist in loading the service with the maximum bit rate it supports without any degradation that is the CIR by definition. Optionally, the user is allowed to configure other test rates smaller than the CIR. For colored services, the only traffic color to be generated in the CIR test is green.

CIR test results are made up of the IR, FTD, FDV and FLR for all the test loads. The test is considered to pass if the computed performance metrics (FTD, FDV and FLR) are better than the corresponding performance thresholds. Test results, including the final Pass / Fail are essentially the same for color aware and non-color aware CIR tests. It is possible to execute several (up to four color-aware or eight non-colour-aware) CIR tests. In this case, CIR tests are executed sequentially for each configured service. To check the CIR test results follow this procedure:

1. From the *Home* panel, go to *Results*,
   The test port results panel is displayed.
2. Select either *Port A or Port B* to enter in the port specific results.
   Note: If you have configured *Test method* to *One-way (A > B),* the eSAM results are available in *Port B*. On the other hand, if you have configured *Two-way (A > A)*, the RFC 2544 results are available in *Port A*.
3. Select *eSAM*.

4. Check the *Status* field to know the pass / fail test result. If the test has not yet finished, this field will display a *In progress* message. If the equipment detects an error during text execution it will display an error message.
5. Check the *Test remaining time* to get an estimation about how much time is left to finish the current test.
6. Go to *eSAM Configuration test*.
   A table with eSAM configuration test results is displayed.
7. Use the *Test-* (*F1*) and *Test+* (*F2*) contextual keys to select the eSAM CIR test results. Use the *Serv-* (*F3*) and *Serv+* (*F4*) contextual keys to select the table corresponding to the service you want to check.

EIR Configuration Test

The purpose of the EIR Configuration test is to measure network performance when it is loaded with an information rate that matches the CIR + EIR. Unlike it happens with the CIR configuration test, the way the results are computed is very different for color-aware and non-color-aware services. The reason is that there is no performance limit in non-colour-aware services when the transmission rate is above the CIR but for color-aware services it is still possible to guarantee the quality of service of green frames. The EIR test is executed and evaluated as follows:

- *Non-color-aware services*: The network is loaded with a CIR + EIR bit rate and the IR, FTD, FDV and FLR are measured. The test is considered to pass if CIR * (1 - FLR) < IR < CIR + EIR.
- *Color-aware services*: The network is loaded with CIR green traffic and EIR yellow traffic. The IR, FTD, FDV and FLR is measured for both traffic classes. The test is passed if the FTD, FDV and FLR for green traffic are within acceptable limits.It must be noticed that performance metrics are always measured but they are relevant for the pass / fail results only for guaranteed (green) traffic.

It is possible to execute several (up to four color-aware or eight non-colour-aware) EIR tests. In this case, EIR tests are executed sequentially for each configured service. Users may not want to run the EIR test. To do that, they have simply to configure the EIR to 0 for services where the test is not going to be executed.

The procedure to follow to display the EIR test results is similar than for the CIR results but in this case it is necessary to use he *Test-* (*F1*) and *Test+* (*F2*) contextual keys to select the eSAM EIR test results rather than the CIR ones

Policing Configuration Test

The Policing test is useful to make sure that the network drops non-conforming (red) traffic. The policing test loads the network with a policing rate computed automatically as specified in ITU-T Y.1564. The policing test is always

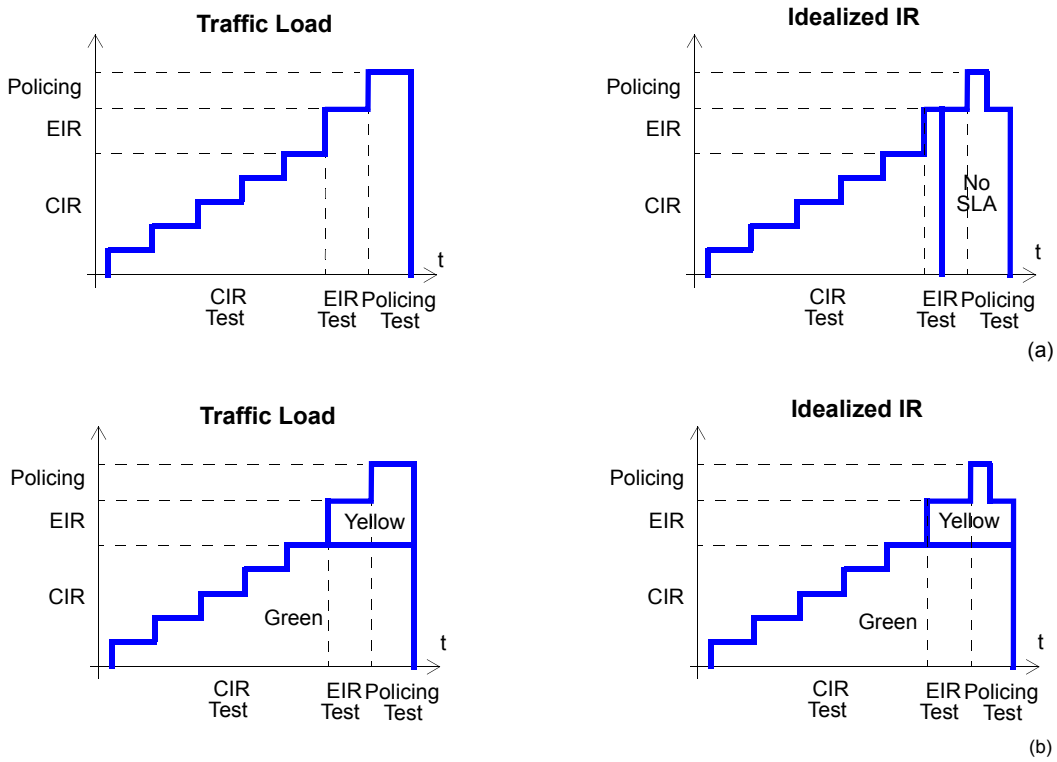

Figure 8 *Typical CIR, EIR and Policing tests in colorful and colorless interfaces: (a) No colors are defined in the interface. Some traffic may be degraded if CIR < IR < EIR because quality of service is not guaranteed for excess traffic. If IR > EIR some traffic will be lost due to the action of the policing filter. (b) Colored interface: Yellow traffic does not have quality of service guarantees but SLA is meet for Green traffic as long as the IR remains smaller than the CIR.*

higher than the sum of the CIR and the EIR. Again, test execution and result presentation is different in color-aware and non-color aware services. Details are as follows:

- *Non colour-aware services*: The network is loaded with a CIR + EIR + policing bit rate and the IR, FTD, FDV and FLR are measured. The test is considered to pass if CIR * (1 - FLR) < IR < CIR + EIR + 1%. The extra 1% is used to account for the burstability of policing filters due to an EBS parameter different to zero.
- *Color-aware services*: The network is loaded with CIR green traffic and EIR + policing yellow traffic. The IR, FTD, FDV and FLR is measured for both traffic classes. The test is passed if the FTD, FDV and FLR for green traffic are within acceptable limits and if the aggregated IR (green + yellow) meets the following double inequality: CIR * (1 - FLR) < IR < CIR + EIR + 1%.

Like it happens with the CIR and EIR tests, it is possible to execute several (up to four color-aware or eight non-colour-aware) policing tests. In this case, policing tests are executed sequentially for each configured service. Users may choose to disable the policing test if the network is not using any admission control mechanism based on policing filters. The policing test fails if it is executed in networks not supporting policing.

The procedure to follow to display the policing test results is similar than for the CIR results but in this case it is necessary to use he *Test-* (*F1*) and *Test+* (*F2*) contextual keys to select the eSAM policing test results rather than the CIR ones

Performance Test

The eSAM performance test is executed only if the configuration CIR, EIR and policing tests are passed. While configuration tests take a few minutes to finish, a performance test may take hours or even days depending on the test requirements.

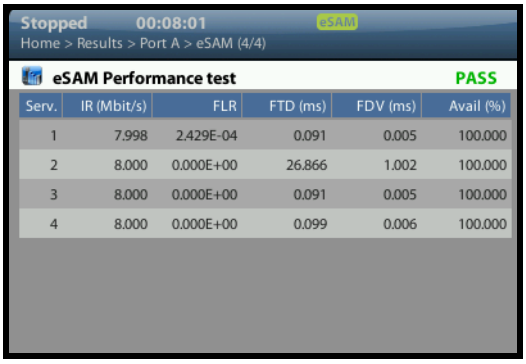

Figure 9 *Performance results as presented by ALBEDO testers.*

In some ways, the performance test is similar to the CIR test because in the network is loaded with the CIR bit rates of all configured service but in this case all services are tested simultaneously and therefore the total load is the sum of all CIR rates for all Ethernet services under test. This is important because a network may be able to support all services if they are not all them loaded at the same time but it may fail to support all services operating at maximum speed. The second difference between CIR and performance tests is that performance test uses to be long enough to compute a significant availability figure.

The performance test computes the IR, FTD, FDV, FLR and availability for all the services being tested. The test is passed if all performance metrics are found to be within acceptable limits. The procedure to follow to display the performance test results is similar than for the CIR results but in this case it is necessary to go the *eSAM Performance test* result panel rather than to the *eSAM Configuration test* panel.

ALBEDO Telecom

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