The Verification Experts

WHITE PAPER

Y.1564:
SAM Demystified

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1. Introduction

If you happen to look at any of the instruments offering the ITU-T Y.1564 Service Activation Methodology (SAM) test suite, you may at first be surprised by the flurry of new acronyms (CIR, EIR, SAC, CM, etc.). Although intimidating at a first glance, you should be aware that there is hardly anything new, it is mostly a naming exercise of legacy concepts. The objective of this paper is to provide a clear understanding of the definitions and methodology of Y.1564, so that no technician feels left behind.

2. Why SAM?

After a decade of RFC2544, you may have learned to appreciate it, or not. Either way, thanks to a genuine need for a better test methodology and a heavy marketing campaign by the SAM inventors, the RFC2544 era of domination seems to be over.

RFC2544, the IETF standard for *"Benchmarking Methodology for Network Interconnect Devices"*, as its name indicates, was designed to test networking equipment in a lab environment. It was later unofficially adopted to test Ethernet lines that were emerging as carriers' service offerings. The newer ITU-T Y.1564 SAM was created to specifically address packet-based services and overcome the RFC2544 shortcomings:

- The carriers' service offering has evolved to take advantage of the technology's flexibility by providing to their customers services below the line rate and by combining multiple services onto a single line. RFC2544 was limited to test at the maximum throughput line rate and for a single service, whereas SAM allows more realistic generation of multiple concurrent streams with bandwidth granularity from 0 up to the line rate.
- The Frame Delay Variation, also known as (packet) jitter was not included in RFC2544. Jitter is a critical parameter for real time voice and video services. It is now part of the SAM test suite.
- RFC2544 validates the service parameters like frame loss, throughput and latency, one after the other, while SAM allows testing all the service critical parameters simultaneously. This results in significant time saving compared to RFC2544.

3. Important Definitions

Service

Unlike RFC2544, the SAM test suite is designed to test a Service rather than a Line. The Service connects customer sites with a 10/100/1000 or 10G Ethernet interface; it is also referred to as EVC (Ethernet Virtual Connection) in the MEF standards. The EVC allows provisioning rates below the Ethernet line rate. In this fashion, the customer only pays for the bandwidth necessary for the applications while the carrier can combine traffic from multiple customers or multiple applications onto a single line. Bandwidth can also be added by remotely re-provisioning the service.

The Service is defined by a set of attributes that specify how the service traffic frames will be handled, prioritized, and delivered within the carrier network.

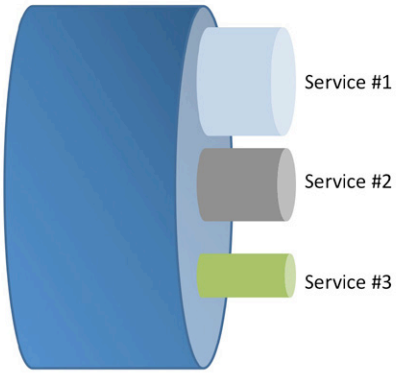


Figure 1. *Ethernet Services*

In the standard, the Service bandwidth is referred to as a **Bandwidth Profile** and the SLA parameters are referred to as **Service Acceptance Criteria** (SAC).

Bandwidth Profile
The Bandwidth profile specifies how much traffic the customer is authorized to transmit and how the frames are prioritized within the network.

The following values fully describe the service's Bandwidth profile: **Committed Information Rate (CIR), Excess Information Rate (EIR), Committed Burst Size (CBS), Excess Burst Size (EBS), Color Mode (CM)**

Committed Information Rate (CIR)
The CIR value in Gbps, Mbps, or kbps describes the guaranteed maximum rate at which the customer can send frames that are assured to be forwarded through the network without being dropped.

For example, if the customer subscribes to a service with a CIR of 100Mbps, as long as the traffic rate is between 0 and 100Mbps, the frames are guaranteed to reach the destination. Within the carrier network, the frames conforming to the CIR rate will be tagged as "green" and given preference over other types of traffic. For more information on how the Information Rate is computed, see the Annex at the end of this document.

Excess Information Rate (EIR)
The EIR value in Gbps, Mbps, or kbps describes the maximum rate above the CIR at which the customer can send frames that will be forwarded on a best effort basis, but may be dropped in the event of congestion within the network. Traffic beyond CIR + EIR will be dropped when it enters the carrier's network.

For example, if the customer subscribes to a service with a CIR of 100Mbps and an EIR of 50Mbps, as long as the traffic rate is between 0 and 100Mbps, the frames are guaranteed to reach the destination. If the traffic rate is between 100 and 150Mbps, the first 100Mbps are guaranteed to be forwarded and the extra 50Mbps will be forwarded on a best effort basis without guarantee. Within the carrier network, the frames conforming to the EIR rate will be tagged as "yellow" and won't be given preference over other types of traffic. Traffic in excess of 150Mbps will be dropped by the carrier at the ingress point to avoid interfering with other services. This is also called the "red" traffic.

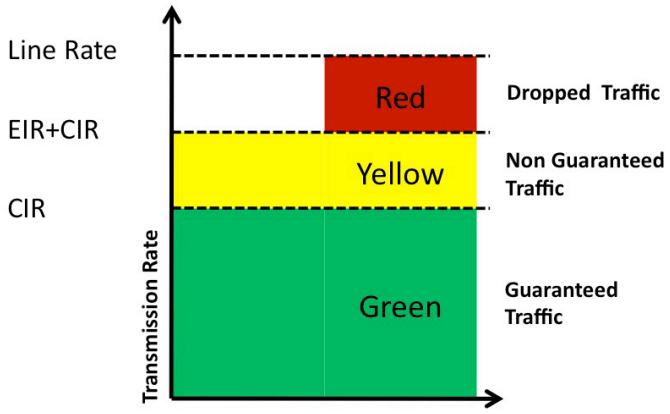


***Figure 2**. CIR, EIR, and Traffic policing*

Committed Burst Size (CBS)
The CBS value in GBytes, MBytes, or KBytes describes the maximum number of consecutive frames sent at full line rate that the service is allowed to transmit and that are assured to be forwarded.

For example, if the customer subscribes to a service with a CIR of 100Mbps and a CBS of 200KB on a 1Gbps line, the traffic transmitted at full line rate (i.e. 1000Mbps) is guaranteed to be forwarded by the network up to burst of 200KB data (e.g. with 1518-byte frames, that would be a total of 131 frames).

This is useful because network traffic is bursty in nature (for example file transfer) and if the customer does not deploy a traffic shaping mechanism that "equalizes" the rate before entering the carrier's network, the traffic could be dropped if it exceeds the CIR+EIR even temporarily. The CBS allows for a "buffer" that can hold a burst of traffic.

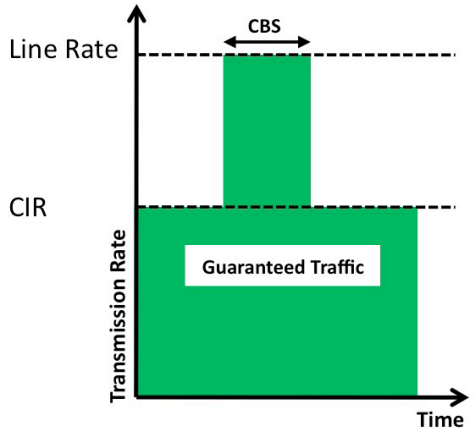


Figure 3. *Committed Burst Size*

Excess Burst Size (EBS)
The EBS value in GBytes, MBytes, or KBytes describes the maximum number of frames sent at full line rate on top of the CBS that will be forwarded on a best effort basis, but may be dropped in the event of congestion within the network.

For example, if the customer subscribes to a service with a CIR of 100Mbps, a CBS of 200KB and an EBS of 200kB on a 1Gbps line, the traffic transmitted at full line rate (i.e. 1000Mbps) is guaranteed to be forwarded by the network up to a burst of 200KB data (e.g. with 1518-byte frames, that would be a total of 131 frames), the next 200KB of data (e.g. the next 131 frames at 1518 frame size) will be forwarded on a best effort basis without guarantee.

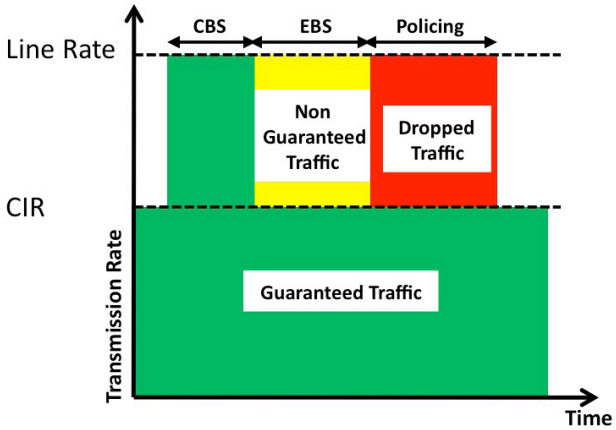


Figure 4. *Excess Burst Size*

Color Mode (CM)

The color mode allows the customer to pre-mark their traffic with a priority tag rather than letting the carrier blindly enforce the CIR/EIR/CBS/EBS algorithm on the traffic.

If the customer chooses a color aware mode, high priority traffic can then be marked with a "green tag" and the lower priority traffic with a "yellow tag" before it enters the carrier network. The carrier will then enforce the CIR, EIR and CBS, EBS functions following the customer markings. Green tagged customer traffic will be allowed up to the CIR and CBS values, and yellow tagged customer traffic will be allowed up to the EIR and EBS values.

For example if the customer subscribes to a service with 100Mbps CIR and 50Mbps EIR, up to 100Mbps of green tagged traffic and up to 50Mbps of yellow tagged traffic can be transmitted. If the customer transmits green tagged traffic beyond 100Mbps, the traffic will be re-marked as yellow by the carrier, or if yellow tagged traffic is transmitted beyond 50 Mbps, the traffic will be dropped by the carrier.

If the customer does not wish to transmit a "colored" traffic, the network will treat all the ingress traffic equally and enforce the CIR, EIR, CBS, EBS values blindly.

Note that there can be several traffic marking mechanisms that can be agreed upon between the customer and the carrier, including VLAN priority tagging, MPLS, or IP DiffServ/TOS.

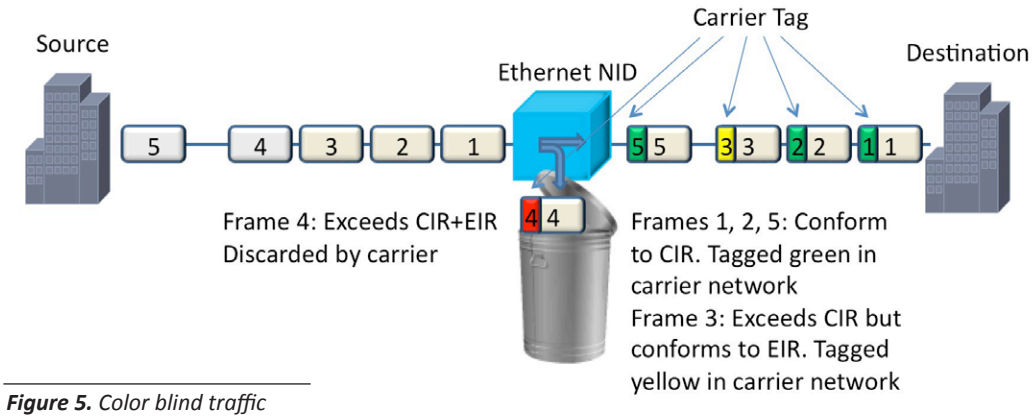


Figure 5. *Color blind traffic*

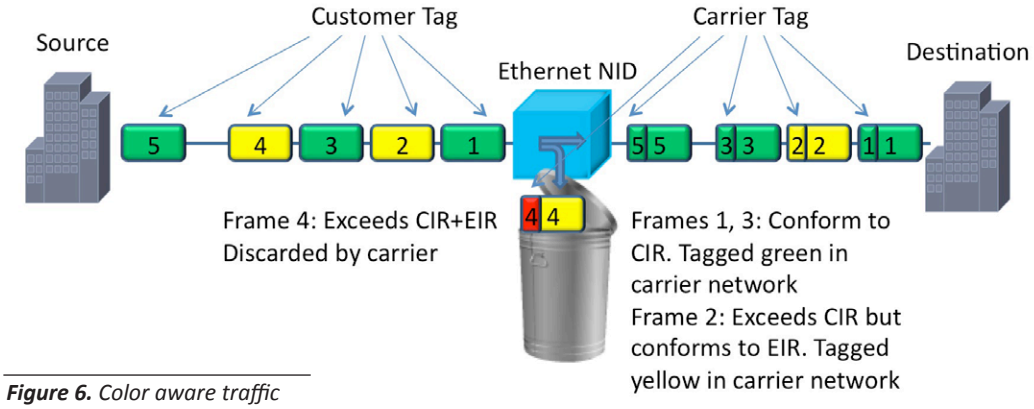


Figure 6. *Color aware traffic*

Service Acceptance Criteria
The service acceptance criteria are a set of parameters defining the performance objectives. This set of values defines the minimum requirements to ensure that the service meets the Service Level Agreement (SLA).

The following values comprise the service acceptance criteria: **Frame Transfer Delay (FTD), Frame Delay Variation (FDV), Frame Loss Ratio (FLR), Availability (AVAIL)**

Frame Transfer Delay (FTD)
The FTD value determines the maximum transfer time that the frames can take to travel from source to destination, and still be compliant with the SLA. FTD is only guaranteed for traffic conforming to the CIR.

FTD can be measured end-to-end if the local and remote test instruments offer a way to synchronize their clocks, otherwise the FTD can be given in terms of round trip delay, where the frame is looped back and returned to its source.

Frame Delay Variation (FDV)
The FDV value determines the maximum frame jitter allowed to still be compliant with the SLA. FDV is only guaranteed for traffic conforming to the CIR.

The FDV parameter is important for streaming voice and video applications, where the value is used to dimension de-jitter buffers designed to compensate for network jitter.

Frame Loss Ratio (FLR)
The FLR value is the maximum ratio of lost frames to the total transmitted frames allowed to still be compliant with the SLA. FLR is only guaranteed for traffic conforming to the CIR.

Availability (AVAIL)
The Availability value is the minimum percentage of service availability allowed to still be compliant with the SLA. The service becomes unavailable if more than 50% of the frames are errored or missing in a one-second interval. Availability is only guaranteed for traffic conforming to the CIR.

Examples of SLA parameters: LTE guidelines Source 3GPP TS 23.203

Scheduling Priority	Traffic	Target Delay	Target Loss Rate
1	IMS Signalling	100 ms	10^{-6}
2	Conversational Voice	100 ms	10^{-2}
3	Real Time Gaming	50 ms	10^{-3}
4	Conversational Video (Live Streaming)	150ms	10^{-3}
5	Non-Conversational Video (Buffered Streaming)	300ms	10^{-6}

Table 1. *LTE SLA*

4. Test Methodology

The purpose of the SAM test suite is to verify that the service is compliant to its Bandwidth Profile and Service Acceptance Criteria. The test is broken down into two phases:

Phase 1: Service Configuration test. The services running on the same line are tested one by one to verify the correct service profile provisioning.

Phase 2: Service Performance test. The services running on the same line are tested simultaneously over an extended period of time, to verify network robustness.

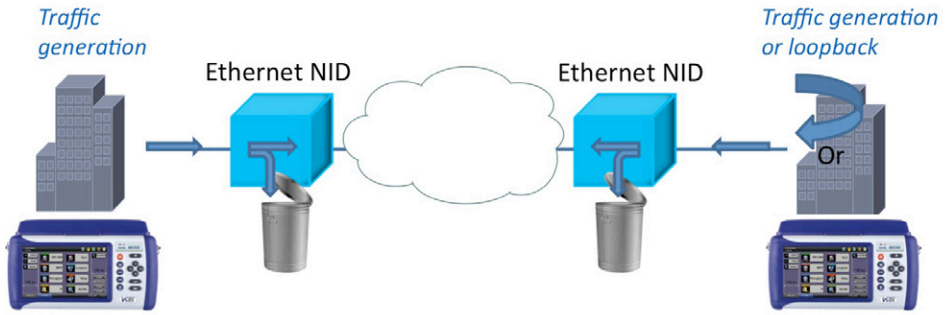


Figure 7. *Test Application*

Phase 1: Service Configuration Test
The service configuration test is broken down into three ***Steps***. The steps are tested individually for all the services delivered on the same line.

Step 1 ***CIR Test***
Traffic is transmitted at the CIR for a short period of time and the received traffic is evaluated against the Service Acceptance Criteria (FLR, FTD, FDV) measured simultaneously. The CIR test passes if the measurements on the received traffic stay below the performance objectives.
Variant: CIR test can also be run in ramp mode, where the traffic rate is increased until it reaches the CIR.

Step 2 ***EIR Test***
Traffic is transmitted at the CIR+EIR rate for a short period of time; the EIR test passes if the received traffic rate is between the CIR (minus the margin allowed by the FLR) and CIR+EIR.
Variant: If the customer traffic is configured for color aware mode, the EIR test will measure the Service Acceptance Criteria (FLR, FTD, FDV) for the green tagged traffic (transmitted at CIR) and the yellow tagged traffic (transmitted at EIR). The EIR test passes if the green tagged traffic measurements stay below the performance objectives (FLR, FTD, FDV).

If no EIR is granted for the service, this Step is skipped.

Step 3 ***Traffic Policing or Overshoot Test***
The purpose of the Traffic Policing Test is to ensure that when transmitting at a rate higher than the allowed CIR+EIR, the excess traffic will be appropriately blocked to avoid interference with other services. For this test, traffic is transmitted at 25% higher than the CIR+EIR for a short period of time. The test passes if the received traffic rate is at least at the CIR (minus the margin allowed by the FLR) but does not exceed the allowed CIR+EIR.

Variant: If the customer traffic is configured for color aware mode, the traffic policing test will measure the Service Acceptance Criteria (FLR, FTD, FDV) for the green tagged traffic (transmitted at CIR) and the yellow tagged traffic (transmitted at EIR). The Traffic Policing test passes if the green tagged traffic measurements stay below the performance objectives (FLR, FTD, FDV) and the sum of the green and yellow tagged traffic rates does not exceed the CIR+EIR.

If the carrier does not have means to enforce Traffic Policing, this Step is skipped.

At this time the CBS and EBS tests are considered experimental and not an integral part of the standard.

Phase 2: Service Performance Test
The Service Performance test ensures that the network can sustain all the services at their maximum committed rate simultaneously for an extended period of time (15 minutes to 24 hours).

Traffic is transmitted at the CIR for all the configured services, the received traffic for each service is evaluated against the Service Acceptance Criteria (FLR, FTD, FDV, AVAIL) measured simultaneously. The Service Performance test passes if the measurements on the received traffic stay below the performance objectives for all the services.

5. Strength of a SAM Tester

VeEX Inc. version of the Y.1564, named VSAM (after VeEX SAM) has been designed with the end user in mind. Our goal is that technicians will be able to quickly provision, run and analyze the test results, even without prior detailed knowledge of the standard.

- Test profiles can be stored and recalled, and even created offline on a PC and loaded on the test set, to facilitate quick setup.
- A visual Pass/Fail banner and summary tables provides a quick overview of the status of all services.
- Color highlighting the failing parameters facilitates a quick understanding of the problem if troubleshooting is required.

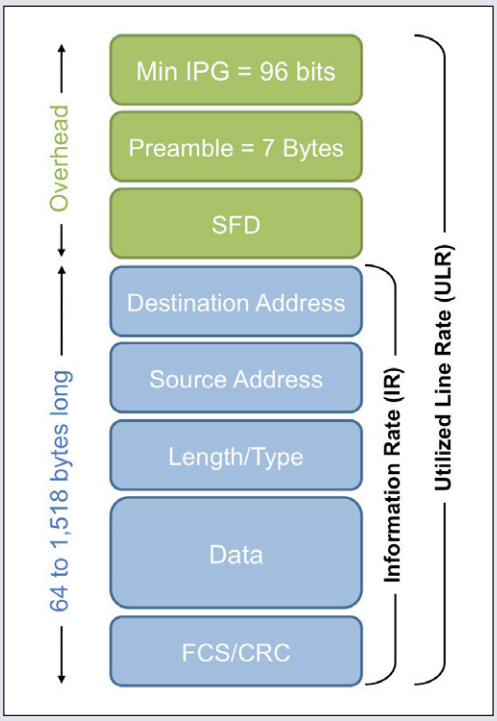
Figure 8. *VeEX VSAM application*

Annex: Ethernet Rate Measurement

Framed rate, data rate, line rate, utilization rate –you will find almost as many definitions as there are equipment vendors. To clear this problem, Y.1564 defines without ambiguity the rate measurement criteria.

- The rates (CIR, EIR) can be expressed in terms of Information Rate (IR) or Utilized Line Rate (ULR).
- The IR measures the average Ethernet frame rate starting at the MAC address field and ending at the CRC.
- The ULR measures the average Ethernet frame rate starting with the overhead and ending at the CRC.

For example on a 100 Mbps line, at 1518-byte frame length, the maximum IR is 98.7Mbps and at 64-byte frame length, the maximum IR is 76.19Mbps, whereas the maximum ULR stays constant at 100Mbps.



About VeEX

Located in the heart of Silicon Valley, VeEX provides innovative test and measurement solutions for next-generation communication equipment and networks. Founded in 2006 by test and measurement industry veterans, VeEX builds products that blend advanced technology and vast technical expertise with the discerning measurement needs of customers.

VeEX core expertise and product lines range from DSL, Broadband and Cable TV to Metro and Next Generation Transport Networks. VeEX's multinational structure consists of several specialized business units operating in different parts of the world. VeEX has shipped more than 15,000 units since volume production began.

Industry consulting firm Frost & Sullivan has benchmarked VeEX against other leading test and measurement companies. As a result, among other awards, VeEX is the proud recipient of the 2009 Global Gigabit Ethernet Test Equipment Price Performance Value of the Year, 2009 Global xDSL Test Equipment Entrepreneurial Company of the Year Award, and the 2008 Global Test & Measurement Emerging Company of the Year.

The VeEX team brings simplicity to tomorrow's networks.

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