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Protect Your Services with Application-Layer Testing

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As networks and applications get more complex, is it time to rethink conventional performance testing?

Imagine the following scenario: A network operator deploys a sophisticated set of service offerings over XGS-PON, including retail broadband services to consumers and business customers as well as wholesale offerings to other service providers. The upstream performance of this varied mix of services is controlled via an equally sophisticated set of Dynamic Bandwidth Allocation (DBA) algorithms, designed to meet the Service Level Specifications for business customers, provide unprecedented control to tenant service providers, and still meet service expectations for consumers on the PON. The service is designed to take advantage of the PON Abstraction Interface specified in TR-402 and TR-403, and lab testing with traffic at volumes that account for growth over the expected life of the service demonstrates pristine performance. Initial field trials are equally successful, and the network is deployed at scale.

For the first couple of years, performance exceeds everyone's expectations. As traffic volumes increase from one year to the next, however, intermittent issues are reported with increasing frequency. Customers start to complain about issues like interruptions and poor picture quality during video streaming. Tenant operators report issues from their own customers, causing repeated rounds of debugging and finger pointing between multiple tenants and the network operator. Meanwhile, dissatisfied customers post negative reviews and take their business elsewhere.

What went wrong? And, how could this situation have been prevented?

A scenario like this highlights the kinds of issues that can be missed with conventional performance testing:

- When an access network is oversubscribed – as virtually all access networks are – it is impossible to test performance with all services carrying worst case traffic at the same time. Even if it was possible, it wouldn't be desirable, since the resulting network requirements would be unnecessarily harsh and impractically expensive.

- In the absence of worst-case testing on the full network, subnetworks and individual nodes may be tested with traffic to simulate a local worst case. But this kind of testing can only minimally exercise DBA algorithms, which are designed to dynamically assign grants to different Optical Network Terminals (ONTs) based on momentary load conditions.

- Testing with randomized Layer 2/3 traffic can represent a further improvement that more fully exercises the DBA algorithms. But how well does this traffic represent the conditions experienced in the field?

- Many applications generate traffic that changes from one instant to the next – and applications themselves can be sensitive to the time domain response of the network. When the effects of application behavior, algorithms like DBA, and network buffers and schedulers all come together, the Quality of Experience (QoE) seen by subscribers can be affected in surprising ways.

In this scenario, it turned out that there was a mismatch between the ONTs' buffers and the scheduling algorithms for DBA that caused multiple upstream packets to be delayed or dropped under specific traffic conditions. Unfortunately, these conditions didn't occur during lab testing or with the traffic loads experienced in initial deployments, but they appeared with increasing frequency as traffic loads grew over time.

Application-Layer Testing assures the highest Quality of Experience

Application-Layer Testing (ALT) models and procedures are being specified in the Broadband Forum to help expose these kinds of issues in lab testing, before they become problems in the field. With ALT, traffic is generated based on models that emulate the behavior of applications and users, creating realistic traffic patterns that exhibit complexity beyond the reach of conventional test methods. Since traffic is emulated, labs can test future loading conditions and explore scenarios with different mixes of user and application types. In addition, ALT defines measurements designed to detect degradation in application QoE even when the underlying network seems to be operating within acceptable limits.

How can industry stakeholders use ALT to maximize the value of their products and services?

- Network operators and service providers can specify ALT models and methods in their test processes and require the same from their vendors. They can also work with the BBF to define use cases and prioritize the applications and metrics for implementation.

- Equipment and software vendors can use ALT to test features like DBA, as highlighted above. They can also verify the performance of network functions implemented on a virtualization infrastructure, as well as the proper orchestration of resources in bursty and rapidly varying traffic conditions.

- Test system vendors can incorporate the models and control plane features associated with ALT standardization to add significant value to test cases at the application layer, opening up new application areas for their solutions.

First and foremost, all stakeholders are encouraged to work with the BBF so that Application-Layer Testing will be specifiable, portable, and repeatable. In support of these goals, the BBF has laid the groundwork with on the following projects:

- TR-421, which was published in 2019, specifies the architecture and requirements to be met by an ALT solution. It describes use cases, data models, test methodologies, and metrics.

- TR-424 will define the data models necessary to specify ALT test cases.

- TR-422 will describe best practices and other information useful to implementers.

- Finally, the BBF is creating an open source reference implementation for ALT control, including generation of data profiles and related test control.

Now consider how the above scenario might have played out with ALT: A network operator plans to deploy the sophisticated set of service offerings described above, including consumer, business, and wholesale services over XGS-PON. The network architecture is designed, and DBA algorithms are developed. Initial lab testing using conventional methods looks good, but a second round of testing using ALT detects intermittent degradation in streaming video performance as well as intermittent upstream packet loss in the network. Analysis uncovers a mismatch between the DBA algorithm and the ONTs' buffer settings, which is corrected. Subsequent rounds of testing confirm that the problem has been resolved.

Initial field trials are successful, and the network is deployed at scale. The network continues to perform as expected over time. Thanks to ALT, everyone – network operator, tenant service providers, consumers, and business customers – is satisfied.

Now is an ideal time to get involved in the development of ALT. BBF participants have the advantage of involvement in development discussions, giving them a head start on understanding and using this material.

If you have an interest in participating, we look forward to working with you. Full details are available at https://wiki.broadband-forum.org (members) and https://broadband-forum.org/membership.