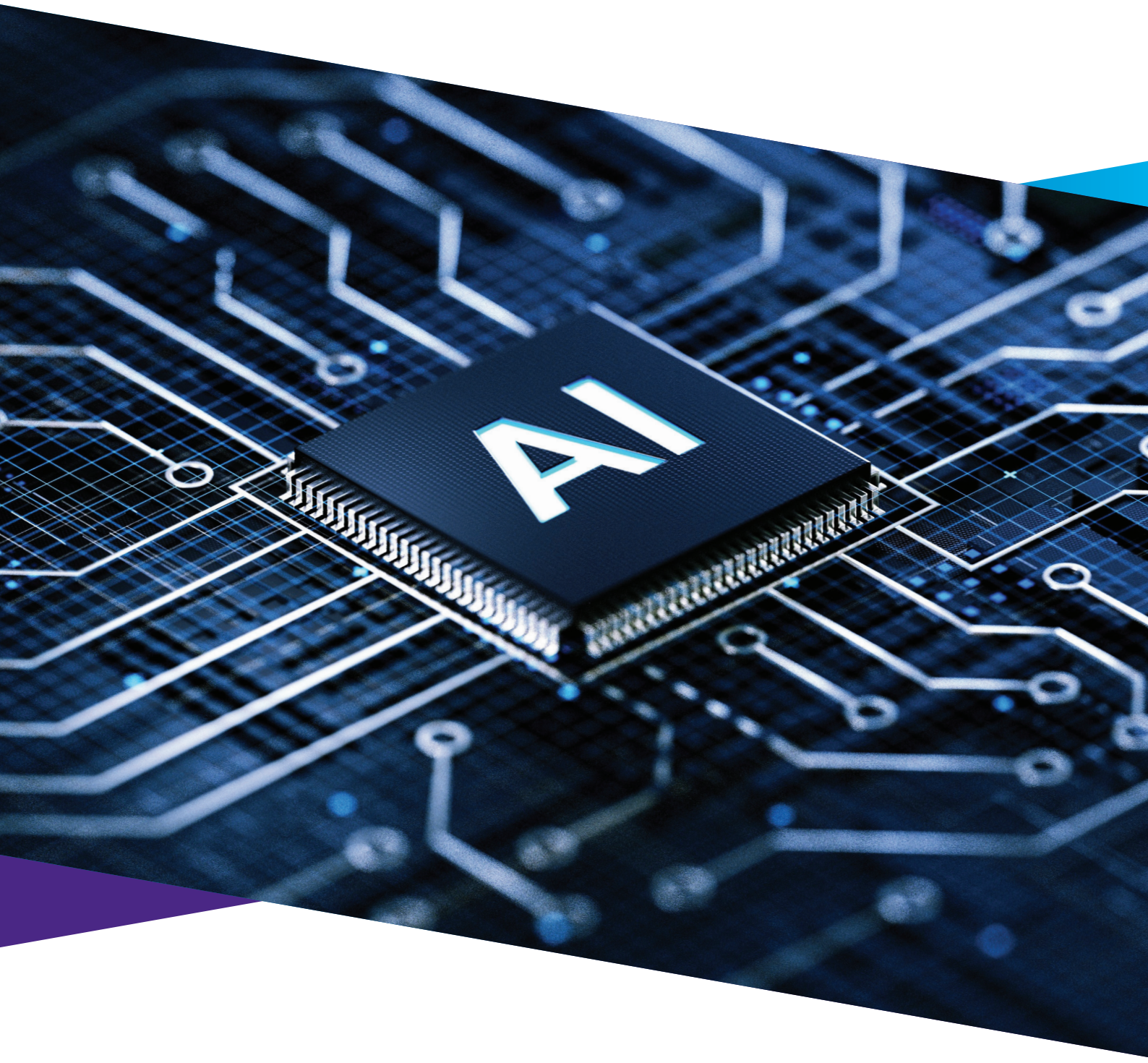
Brochure

UEC Packet Delivery Sub-layer (PDS) Conformance Testing

Ensuring Specification Compliance and Multi-Vendor Interoperability for Ultra Ethernet Deployments



The Ultra Ethernet Consortium (UEC) was established to create an open, Ethernet-based communications fabric optimized for AI and high-performance computing (HPC) workloads. By combining Ethernet's economics and multi-vendor ecosystem with the performance characteristics demanded by large-scale AI clusters, UEC aims to provide an open alternative to proprietary interconnect technologies.

Achieving this vision depends on consistent implementation across silicon, software, and infrastructure vendors. Conformance testing plays a critical role in ensuring that independently developed products interpret and implement the specification consistently, enabling reliable interoperability across the ecosystem.

This document examines conformance testing for one specific, critical piece of the UEC architecture: the Packet Delivery Sub-layer (PDS). What PDS does, why it needs dedicated conformance validation, what such testing typically covers, and where it fits in a broader validation program.

KEY CHALLENGES

Organizations developing and qualifying Ultra Ethernet products face several validation challenges:

- Ensuring consistent implementation of evolving UEC specifications across silicon, software, and infrastructure components
- Validating interoperability in multi-vendor environments before large-scale deployment
- Verifying retransmission and packet trimming behavior under loss and congestion conditions
- Identifying specification ambiguities and implementation errors early in the development cycle
- Establishing objective, repeatable qualification criteria for product acceptance and regression testing

Where the PDS Sits in the UEC Stack

UEC organizes the fabric into a Semantic Layer, a Transport Layer, a Network Layer, and a Link Layer. The Transport Layer itself is split into two cooperating sub-layers: a Congestion Control Sub-layer, responsible for signaling and reacting to fabric load, and the Packet Delivery Sub-layer (PDS), responsible for getting data from one Fabric Endpoint (FEP) to another correctly, in the right order (when required), and efficiently across a multi-path, lossy Ethernet fabric.

The PDS is where Packet Delivery Contexts (PDCs), the connection-like state that tracks an exchange between two endpoints, are created, maintained, and torn down. It is also where UEC's more novel delivery behaviors live: support for both ordered and unordered delivery, selective retransmission instead of go-back-N, and packet trimming, which lets a congested switch strip a packet's payload and forward just the header so the sender can retransmit immediately rather than waiting for a timeout.

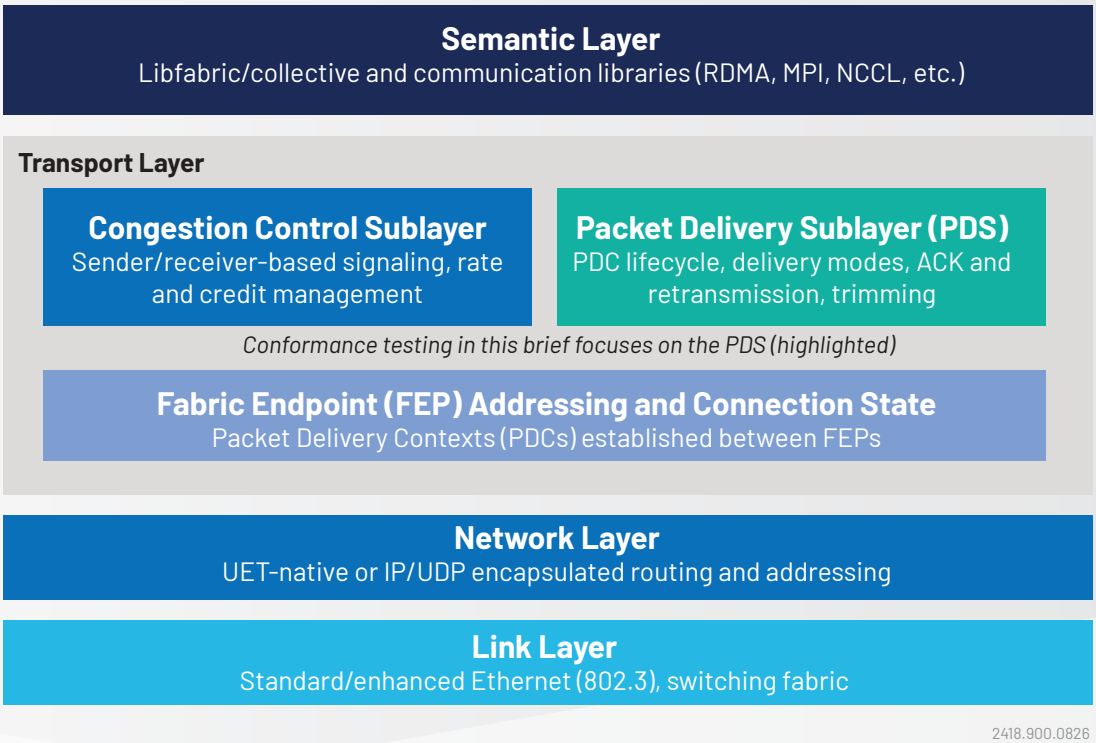


Figure 1: UEC protocol stack, with the Packet Delivery Sub-layer (PDS) highlighted.

Because the PDS sits in the data path and directly influences tail latency, throughput under congestion, and recovery time after loss, any deviation between how one vendor's PDS behaves versus another's shows up immediately in mixed-vendor deployments, sometimes as a hard failure, more often as the harder-to-diagnose kind: intermittent stalls, uneven throughput, or retransmission storms that only appear at scale.

Why Conformance Testing Is Needed

A specification document, however well written, is not a guarantee of consistent implementation. Conformance testing exists to close that gap:

- **Multi-vendor interoperability.** UEC's value proposition depends on NICs, DPUs, and switch ASICs from different vendors working together. Conformance testing validates each implementation against the specification itself, independent of any single vendor's reference behavior, which is what actually enables plug-and-play interoperability instead of pairwise, per-vendor validation.
- **Early defect detection.** Catching a PDC state-machine bug or an incorrect retransmission timer in a lab conformance suite is far cheaper than catching it after deployment in a production AI training cluster, where the symptom might be a job that silently runs slower or a training run that stalls under contention.
- **Specification ambiguity surfaces early.** Running the same test suite against multiple implementations often reveals places where the spec text was open to more than one reasonable reading. That feedback loop to the standards body is part of how a young specification matures.
- **Objective, repeatable acceptance criteria.** For network operators and system integrators qualifying new hardware, a conformance report gives a repeatable, spec-traceable basis for acceptance, rather than relying on informal interoperability bake-offs.
- **Confidence at scale.** Behaviors like trimming and selective retransmission are specifically designed to hold up under congestion. Functional conformance testing at the packet and state-machine level is the foundation that scale and performance testing build on; there is little point in stress-testing an implementation who's basic PDS behavior does not match the specification.

What PDS Conformance Testing Covers

Conformance test suites for the PDS are organized around the sub-layer's core responsibilities:

- **Configuration:** validating that configurable PDS parameters (timers, retry limits, delivery-mode selection, PDC attributes, and similar settings) are correctly negotiated, applied, and enforced.
- **Delivery modes:** verifying correct behavior across the delivery modes UEC defines, including ordered and unordered, reliable and unreliable delivery, and any mode-specific sequencing or completion semantics.

- **PDC lifecycle management:** exercising PDC creation, active-state operation, and teardown, including edge cases such as simultaneous open/close, timeout-driven teardown, and error recovery.
- **ACK management:** checking acknowledgment generation, coalescing, and processing, including cumulative and selective acknowledgment behavior and how the implementation handles out-of-order or duplicate ACKs.
- **Retransmission management:** validating loss detection and selective retransmission logic, retry-limit enforcement, and interaction with timers, under both isolated packet loss and burst loss conditions.
- **Trimming management:** confirming correct generation, recognition, and handling of trimmed packets, and correct recovery behavior once a trim event is signaled to the sender.

Each of these areas map to specific requirements in the UEC specification, and a well-built conformance suite ties every test case back to the clause it validates, so a failure points directly at a specification requirement rather than a vague symptom.

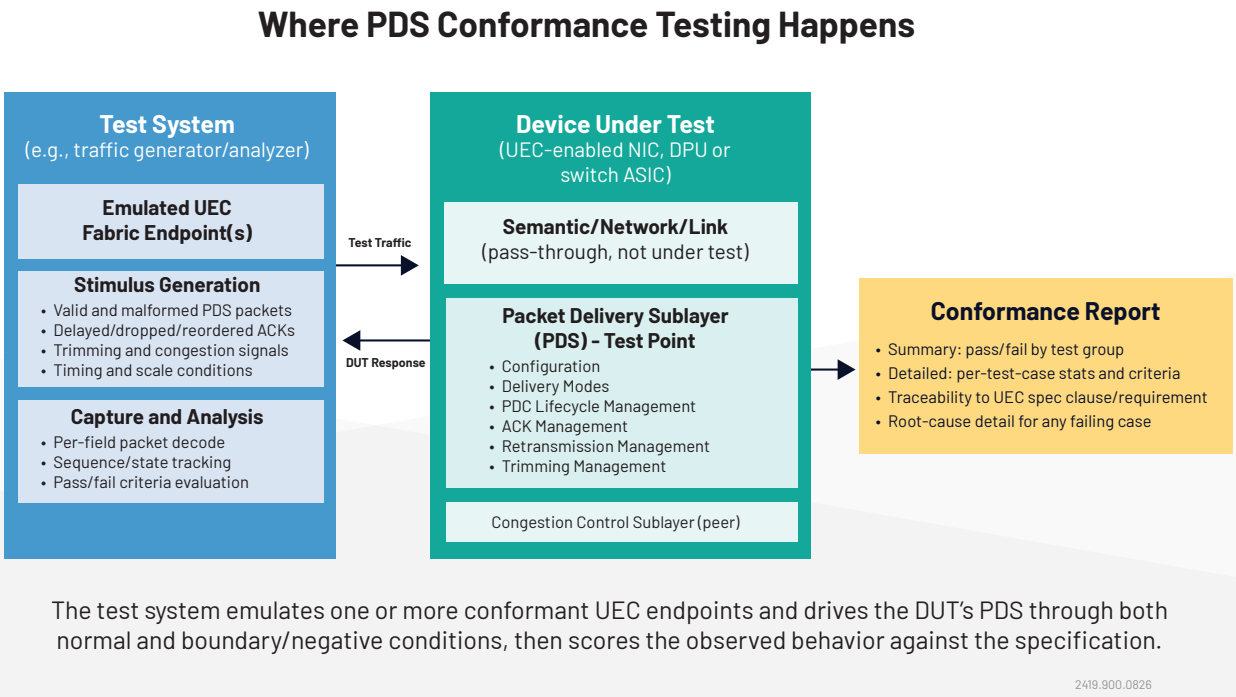


Figure 2: Test topology showing where PDS conformance testing is applied against the Device Under Test.

In practice, this testing is done by placing a test system, emulating one or more conformant UEC Fabric Endpoints, directly against the Device Under Test (DUT), whether that's a NIC, a DPU, or a switch ASIC with PDS-aware behavior. The test system generates both well-formed and deliberately boundary or negative traffic (delayed ACKs, dropped packets, out-of-order delivery, forced trim events) and observes how the DUT's PDS responds, scoring that response against the specification's stated requirements.

Reporting: Making Pass/Fail Traceable

A conformance result is only as useful as the evidence behind it. Good test tooling produces two complementary views:

- A summarized report giving a pass/fail count by test group (configuration, delivery modes, PDC lifecycle, ACK management, retransmission, trimming), useful for a quick go/no-go read on an implementation's overall conformance posture.
- A detailed execution report for each test case, showing the specific statistics or criteria that were measured: timer values observed versus expected, sequence numbers, ACK counts, retransmission counts, trim-event handling, and exactly which measurement caused a pass or a fail.

That level of detail matters because it turns a failure from "test 37 failed" into "the PDC did not retransmit the dropped segment within the expected retry window," which is what an engineering team needs to act on.

Use Cases

- Silicon and IP validation during NIC, DPU, or switch ASIC development, run repeatedly through the design cycle as PDS logic changes.
- Pre-interoperability qualification, so that plugfests and multi-vendor bake-offs start from implementations that are already individually conformant, rather than debugging basic spec deviations in a shared lab.
- Vendor and product qualification by network operators and system integrators evaluating UEC-capable hardware for procurement.
- Regression testing against firmware and driver updates, to confirm that a PDS implementation that passed conformance once continues to pass it as the codebase evolves.
- Specification development support, feeding discrepancies and ambiguities back to the UEC working groups as the specification itself matures through revisions.

VIAVI UEC Conformance Validation

VIAVI TestCenter helps organizations validate UEC implementations through an automated Functional Compliance Suite covering key Packet Delivery Sub-layer behaviors, including configuration, delivery modes, PDC lifecycle management, ACK processing, retransmission handling, and trimming operation.

The solution provides both high-level conformance summaries and detailed test execution reporting, enabling engineering teams to quickly identify, diagnose, and resolve specification deviations before deployment or interoperability testing.

Benefits of PDS Conformance Testing

- Improve confidence in multi-vendor interoperability
- Identify implementation issues earlier in development
- Accelerate product qualification and interoperability readiness
- Simplify root-cause analysis through specification-traceable reporting
- Reduce deployment risk in AI and HPC network fabrics

Learn how VIAVI TestCenter enables UEC conformance validation and comprehensive AI fabric testing, including interoperability, congestion management, RoCEv2, collective communication workloads, and Ultra Ethernet Transport (UET) validation.

Learn More

- UEC Validation Solution Datasheet
- AI Data Center Networking Test Solutions

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