NEPTUNE

A New Approach to Optical Fiber Connectivity Monitoring

1 THE PROBLEM

Modern data centers rely almost exclusively on optical network adapters and fiber-optic cables to connect servers and network infrastructure. A typical data center may contain hundreds of thousands of servers and millions of individual network connections.

Optical networking provides substantially higher bandwidth and lower latency than traditional copper-based networking, but it also introduces significant installation and maintenance challenges. The physical installation and maintenance of fiber-optic links is more demanding than for copper, since connectors, splices, and terminations must be carefully installed and maintained to keep optical losses within specification. The fibers themselves are physically fragile, and their optical properties can degrade over time.

The following fiber-connectivity monitoring and troubleshooting methods are currently available to data center operators.

Manual Testing

Manual testing typically involves an Optical Time-Domain Reflectometer (OTDR) and/or an Optical Loss Test Set (OLTS) to determine whether a fiber is intact and whether its optical loss is within the acceptable range. This process requires qualified personnel, can generally test only one fiber at a time, and requires downtime because the fiber must be physically disconnected from the network equipment.

Active-Side Monitoring

Some switches on the market can be configured to copy and capture network traffic from selected ports on the active side, after the optical signals have been converted into data packets. This approach is expensive because it requires additional infrastructure for processing and analyzing the captured data, typically provided by the equipment vendor. It also introduces security concerns because network traffic is exposed to an additional system and potentially to a third party.

Optical Splitting

Another approach is to split the optical signal into two channels: one for normal data transmission and one for monitoring. This approach has similar drawbacks. It is expensive because it effectively reduces the number of ports available to the application network, and it either requires clients to handle the monitoring traffic themselves or introduces a potential security vulnerability by giving a third party access to network data. In addition, optical splitting introduces additional signal loss by diverting a portion of the optical power away from the receiver.

There is currently no commercially available solution that provides continuous, real-time, out-of-band visibility into the physical state of individual optical fiber links or detects gradual degradation before it results in a failure, without interfering with network traffic or introducing additional security risks.

2 OUR SOLUTION

Optical fibers operate on the principle of total internal reflection, which confines most of the light to the fiber core. A small fraction of the optical energy, however, is present outside the core as a result of the physical properties and manufacturing characteristics of the fiber.

We have developed a method for reliably detecting this light outside the fiber, enabling non-intrusive detection of the presence or absence of an optical signal within the fiber. Based on this method, we designed Neptune, a new optical fiber monitoring solution that is intended to meet the following requirements:

- Provides continuous, real-time visibility into the physical state of each individual fiber;
- Detects degradation of fiber properties, allowing problematic fibers to be proactively replaced during scheduled maintenance;
- Does not interfere with network traffic;
- Has no access to network data packets, eliminating the associated data-security exposure;
- Has a low per-channel cost and can scale to data centers of any size;
- Uses hardware installed in standard passive network components, such as cassettes and optical distribution frames (ODFs), facilitating integration into existing installations;
- Exposes a well-defined API, making it straightforward to integrate with existing data center asset-management and monitoring systems.

In addition, Neptune can provide several capabilities beyond continuous fiber monitoring:

- Maintains a complete history of physical network configuration changes, supporting audit, compliance, and physical security monitoring;
- Provides an independent means of verifying the actual physical network topology against a specified configuration;
- For new installations, can simplify cabling and connectivity verification during deployment and commissioning.

Our long-term objective is for Neptune to become a standard component of optical infrastructure in data centers. Broad adoption would enable fiber monitoring to become an integrated part of data center design, construction, commissioning, and ongoing operations.

3 PROJECT TIMELINE AND BUDGET

We have established proof of capability with a prototype system in which two active network devices are connected by a duplex optical fiber patch cable, with each fiber channel instrumented by our monitoring device. We conducted multiple tests and verified that the monitor detected the presence and absence of the optical signal as expected, with 100 % detection efficiency and zero false detections, while having no measurable impact on link operation.

Following the successful proof of concept, we prepared a detailed technical description of the underlying method and filed a patent application with the U.S. Patent and Trademark Office.

We are currently extending the method to a minimal real-world scenario in which several active devices are connected to their respective counterparts through the multi-segment optical paths typical of data center installations, with each path monitored independently at both ends.

Our next major milestone is to scale the monitoring system to the capacity of a rack-mounted optical distribution frame (ODF). Our preferred development plan is to build and test two production-quality units in a data center environment with active network equipment, producing a system that can subsequently be demonstrated and marketed to prospective customers. We estimate that this phase will take approximately 12–15 months and require a budget of approximately $4.4M.

A more conservative development path would be to first build a functional full-capacity prototype, while deferring production hardening and data center deployment and testing to a subsequent funding round. We estimate that this approach could be completed in less than one year with approximately half the budget.

4 MARKET POTENTIAL

A modern high-capacity data center can contain millions of individual optical fiber links. If these links were fully instrumented with Neptune at an estimated customer price of approximately $10 per monitored channel, the resulting hardware opportunity could reach tens of millions of dollars per data center.

With the current rapid expansion of data center infrastructure driven in large part by AI workloads, more than a thousand new data centers could be built globally each year. At that scale, the annual opportunity for Neptune across newly built facilities alone could approach $100B, before accounting for the much larger installed base of existing data centers that could be retrofitted with the technology.

5 OUR TEAM

Neptune is driven by a core team of three highly motivated individuals who bring together extensive experience and complementary technical and business expertise.



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Business Proficiency and Global Presence



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