



Anue Systems White Paper Series:

Anue Systems Network Delay Emulators vs. Optical Fiber Spools: A Comparison



Network Emulators

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Abstract:

Spools of fiber optic cable, containing various lengths of unclad fiber – sometimes as long as 200 km – are used in almost every lab where fiber optic networks and network equipment are tested. By connecting each end of the cable to the equipment, a mini “optical network” is created for testing purposes. A number of serious limitations exist with optical fiber spools. The most significant of these is that it is difficult and expensive to replicate the long distances found on actual wide area networks.

Network Delay Emulators from Anue Systems, Inc., provide a compelling alternative to test beds built with fiber spools. Anue Emulators can inject enormous amounts of delay, as well as many types of impairments, in order to model real world network behavior. Delays and errors can be added in a controllable and exact manner, with bit level granularity. The rich functionality, ease of use, and cost-effectiveness of Anue Systems Network Emulators are causing many labs to select Anue Systems instead of adding more fiber spools.

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Introduction

Optical fiber networks are extremely fast, transporting data at 200,000 km/s. Even with new technologies and advances in optical networking, propagation delay still has a tremendous impact on the performance of delivered services such as VoIP and Video. Higher layer protocols like TCP and Fibre Channel, which are essential to applications such as remote data backup and disaster recovery can dramatically degrade in terms of throughput performance or completely shut down as a result of delay.

Equipment manufacturers, service providers and enterprise companies have long utilized spools of fiber to emulate the delays experienced over optical networks. Some companies have literally spent hundreds of thousands of dollars on racks of fiber spools attached to expensive optical amplifiers and optical switching equipment.

These test systems obviously have a number of serious limitations:

- They tend to be large cumbersome systems involving multiple spools plus amplifier equipment sometimes taking up multiple racks in a lab.
- Sharing the test system with other labs or remote locations is nearly impossible leading to duplicate expensive systems for larger companies.
- They have a very limited or restrictive control over delay resolution (based on the lengths of the fiber spools used), which limits testing capability.
- These systems can require a large amount of manual labor to connect or disconnect spools in order to achieve the desired fiber lengths or delay values.
- Each time the system is reconfigured there is the potential for a troubleshooting nightmare with so many connectors involved! This affects test repeatability and makes test cycles long and inefficient.
- Even if an optical switch is used for the purpose of selecting the desired fiber distance (adding cost), the system can not always be easily automated.
- Finally, a piece of in-line test equipment is still needed in order to do any accurate real world impairment emulation, adding even more to the cost!

Anue enables extreme accuracy and precise control with delay tuning down to a single bit or 0.8ns at 1.25Gbps. Tests can be performed easily and repeatedly with different delay amounts.

The Anue Systems Solution

Network Emulators from Anue Systems, Inc. address many of the shortcomings of test systems comprised of fiber spools. Anue Systems testers precisely emulate signal delays and impairments that occur as data is transmitted over optical fiber. With an Anue Emulator “in-line” between two pieces of network endpoint equipment, a user can inject delay (in terms of milliseconds, kilometers, or bits), bit errors (at BERs from 10^{-2} to 10^{-12}), and other impairments (such as packet loss, loss of frame, loss of signal, etc.) in a controlled manner. Anue Systems Emulators are controlled by a GUI, or a TCL command line interface, or via the control panel on the Emulator.

The Anue Systems Emulator is capable of a large amount of delay. The maximum possible signal delay time that an Anue Systems Emulator can generate depends on the data rate and the memory configuration selected. Even the standard memory package on an Anue “Maui” Series Emulator, however, provides up to 500 ms (100,000 km) of delay on one gigabit per second data, and 250 ms (50,000 km) of delay on two or 2.5 (OC48) gigabit per second signals. Optional memory upgrades can double or triple this amount of delay. Also, Anue’s “Hawaii” Series Emulators provide even more delay (up to several seconds), in addition to handling data rates up to 11.3 Gbps.

The amount of delay is just the beginning! Anue Systems enables extreme accuracy and precise control with delay tuning down to a single bit or 0.8ns at 1.25Gbps. Tests can be performed easily and repeatedly with different delay amounts.

The actual delay time that a user desires to emulate depends on several factors, including distance, network congestion, wavelength, and the number of network elements that will be encountered. As a starting point, using the 200,000 km/s assumption for the speed of light in fiber, delay times can be estimated between locations based on geographical distance. Table 1 shows these estimated delay times between major cities. Of course, actual signal delay times will be higher, in some cases much higher, because the data may take an “indirect” path and pass through many network hops each of which can add delay. Nonetheless, as can be seen from Table 1, Anue Emulators are likely to far exceed the delay requirements of any terrestrial network applications.

A number of serious limitations exist with optical fiber spools. The most significant of these is that it is difficult and expensive to replicate the long distances found on actual wide area networks.

One-Way Delay (ms)	Austin	Hong Kong	London	New York City	San Jose	Tokyo	GEO Satellite
Austin		66	40	12	12	53	184 - 214
Hong Kong	66		49	65	56	14	
London	40	49		28	43	48	
New York City	12	65	28		21	54	
San Jose	12	56	43	21		42	
Tokyo	53	14	48	54	42		
GEO Satellite	184 - 214						

Table 1: One way delay times between major cities.

As a result of the advantages described above, Anue Systems Emulators are a superior alternative to fiber spools for many lab testing applications.

Anue Systems Emulators, however, do not simulate changes to the analog, or optical, characteristics of light as it travel over fiber. These impairment aspects, namely optical signal attenuation – the decrease in amplitude of the light pulse – and dispersion – the “spreading or flattening out” of the signal with respect to time – require an additional or alternative test methods. Anue Systems Network Emulators alone will not be used for customers interested in characterizing optical receiver performance under certain dispersion profiles.

Fortunately, emulating these characteristics can be straightforward and inexpensive. Dispersion can be very effectively created with a fiber spool (generally, of a specific kind of fiber) as small as 18 km, or with a Fiber Emulator. Likewise, a simple optical attenuator in many cases can provide more than sufficient attenuation, the amount of which is adjustable.

Table 2 compares the Anue Systems solution with fiber spools across several dimensions important for lab testing.

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Testing Attribute	Anue Network Delay Emulator	Fiber Spools	Comments
Delay amount	High	Low/Med	Can string together multiple 200km spools with repeaters to get a few ms delay. Anue can perform 150,000 km + of delay.
Delay granularity	High	Low	Single bit increments with Anue. Need different spool lengths with fiber.
Bit Errors	High	Low	Need network equipment to inject errors with fiber spools.
Fiber Cut	High	Med	With fiber, can pull out fiber or use an attenuator to simulate a cut.
Packet Drop	High	No	Cannot be done with fiber spools.
Signal Attenuation	Low	High	Must use an attenuator to achieve with Anue.
Signal Dispersion	No	High	Cannot be done with Anue Emulator.
Packet Jitter	Upgrade	No	Available on Anue GEM Emulator.
Packet reorder	High	No	Available on Anue GEM Emulator.
Packet duplication	High	No	Available on Anue GEM Emulator.
Data modification	High	No	Available on Anue GEM Emulator.
Multiple protocols	High	High	
Small size/portability	High	Med	Anue is a 2U chassis. Spools are 2U chassis per 1 ms (200km).
Ease of use	High	Med	Anue has GUI, TCL and front panel control.
Cost	\$30K-\$50K	\$5K/spool	Anue pricing is Bi-Di unit. Each spool is 200km.
Conclusion	Very versatile. Provides enormous amount of delay. Easy to use.	Low cost solution for basic point-point testing	

Table 2: Capabilities of Anue Emulator vs. Fiber Spools.

Anue Network Emulators also save lab space (only 2U high), allowing easy rack mounting or transport around the lab(s). There is no longer a need for multiple optical amplifiers or racks and racks of equipment.

Cost Comparison

The following cost comparison is based on real data we received from one of our Anue Systems customers.

In this example, a test system for emulating 1400 km (or 7 ms) of delay using spools of fiber **in one direction only** required the following:

- 7 fiber spools at 200 km each costing about \$10k each
- 14 optical amplifiers (100km spacing) costing about \$5k each (this depends on optical fiber and amplifiers used)

The total cost for this uni-directional system comes to about **\$140,000!** It should also be noted that this test setup does not include rack and lab space, an optical switch which can cost an additional \$30k to \$100k, and electrical power.

A single uni-directional Anue Systems Network Emulator capable of performing the above test scenario for an OC-48/STM-16 SONET/SDH network would be considerably less expensive – depending on the load the cost comes in at around one fifth of the fiber spools scenario.

Anue Network Emulators also save lab space (only 2U high), allowing easy rack mounting or transport around the lab(s). There is no longer a need for multiple optical amplifiers or racks and racks of equipment.

When comparing the cost of a test setup involving fiber spools with an Anue Network Delay Emulator, the Anue Systems solution compares very favorably.