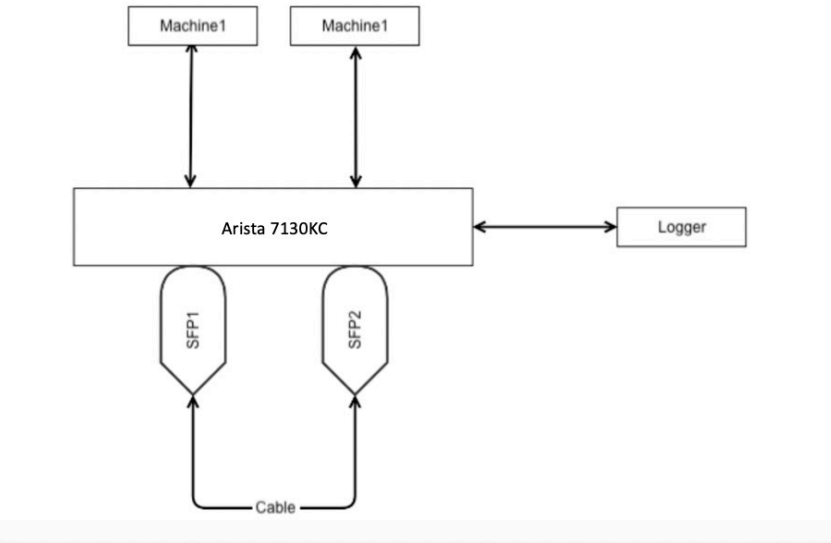
Copper is Faster than Fiber

While fiber can move more data over longer distances, we've used the Arista 7130 MetaWatch network application to show that direct attach copper cables have the edge over both SMF and MMF fiber (which were essentially equivalent to each other).

Our testing setup looks a little bit like this:



We connected two machines to an Arista 7130K Series device with 32 ports and running MetaWatch using 10G Ethernet. We then created a loopback through two ports on the device's front panel, first using direct-attach copper cables, and then using fiber cables. For each cable that we tested, we passed around 1,000,000 "ping" packets through the device, pinging backward and forward between the two test servers.

By measuring the time that each packet passed through MetaWatch, and then correlating those measurements and differencing them, we were able to calculate the time taken for each packet to pass through the device. Each result is pretty accurate: +/- 2 ns, but we averaged the million results we had to get even more accurate numbers.

We used direct-attach copper cables, and SFPs for the test, and generic MMF and SMF fibers -- it's possible that some will be faster than others (including hollow-core fibers, which should be *much* faster).

Note also that these are passive direct-attach cables, not Cat5 1GBase-T or 10GBase-T cables with the corresponding SFPs -- we've measured these types of SFPs to have a very high latency of round 300 ns round-trip, which dwarfs any potential savings from the propagation delay of the copper.

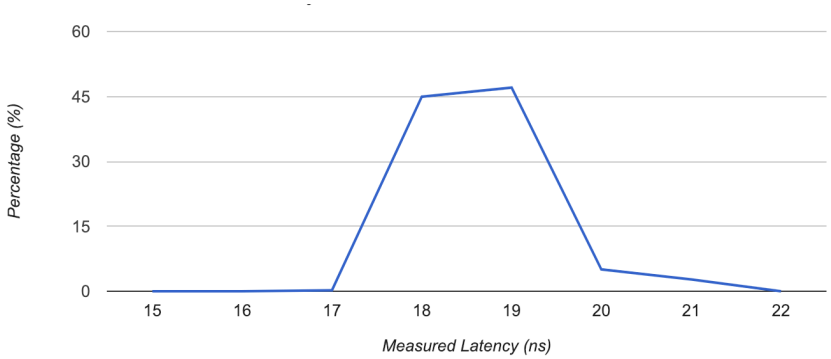
Results

Cable Type	SFPs (1 and 2)	Cable	Distance (m)	Latency (ns)	Description
DAC	N/A	1M Twinax	1.008	7.8345	1.008 m direct-attach copper
DAC	N/A	2M Twinax	2.02	12.3344	2.02 m direct-attach copper
DAC	N/A	3M Twinax	2.998	16.7289	2.998 m direct-attach copper
DAC	N/A	7M Twinax	6.992	34.9989	6.992 m direct-attach copper
MMF	10GBASE-SR	1 m MMF OM1 fiber	1.094	9.4755	1.094 m MMF fiber
MMF	10GBASE-SR	2 m MMF OM1 fiber	2.190	14.9769	2.190 m MMF fiber
MMF	10GBASE-SR	3 m MMF OM1 fiber	3.286	20.4918	3.286 m MMF fiber
MMF	10GBASE-SR	4 m MMF OM1 fiber	4.381	25.7473	4.381 m MMF fiber
MMF	10GBASE-SR	5m MMF OM1 fiber	5.477	31.2473	5.477 m MMF fiber
MMF	10GBASE-SR	6 m MMF OM1 fiber	6.572	36.7727	6.572 m MMF fiber
MMF	10GBASE-SR	7 m MMF OM1 fiber	7.667	42.2407	7.667 m MMF fiber
SMF	10GBASE-LR	2m SMF fiber	2.100	14.4991	2.1 m SMF fiber
SMF	10GBASE-LR	4m SMF fiber	4.200	24.7130	4.2 m SMF fiber
SMF	10GBASE-LR	6m SMF fiber	6.300	35.2940	6.3 m SMF fiber

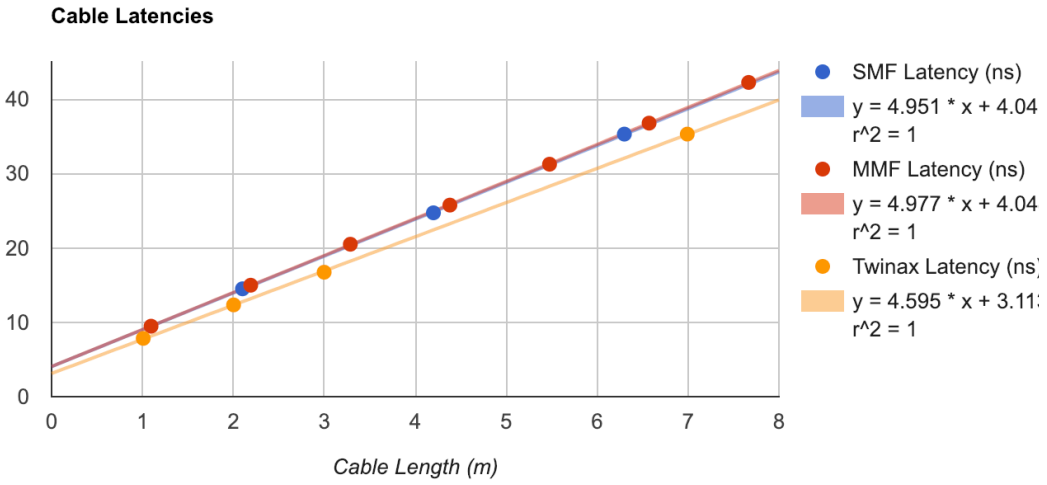
For each test we took 1,000,000 samples. To check that our test setup was accurate, we looked at the distribution of the timestamps captured by MetaWatch and see that it is well formed, with a spread of +/- 4 ns.

Measured Latency (ns)	Sample %
15	0
16	0
17	0.233
18	44.938
19	47.041
20	5.048
21	2.74
22	0

MetaWatch Delta Accuracy



So, if we plot those results and fit a trendline we get slopes and offsets:



Cable Length (m)	SMF Latency (ns)	MMF Latency (ns)	Twinax Latency (ns)
1.008			7.835
1.094		9.47	
2.002			12.334
2.1	14.499		
2.19		14.98	
2.998			16.729
3.286		20.49	
4.2	24.713		
4.381		25.75	
5.477		31.25	
6.3	35.294		
6.572		36.77	
6.992			35.294
7.667		42.24	

Analysis

The trendlines above show that single-mode and multi-mode fiber have near identical latencies of 4.96 ns per meter. This is close to the oft-quoted 5 ns per meter for fiber. The latency for the twinax copper cables shown is 4.60 ns per meter -- faster by about 400 ps per meter. What's also interesting is the zero-offset. When we extrapolate down to a hypothetical 0 m cable, the copper cables have a lower fixed offset compared with the fiber. We consider the copper direct-attach cable to have zero latency in the SFPs, since the twinax cable is soldered directly to the pins on the SFP module itself.

The difference between the offsets is about 1 ns (copper shows an offset of 3 ns, which we believe is a mis-calibration in the MetaWatch device). This is due to the latency in the SFPs themselves. Note that the latency is nearly identical for both the SR and LR SFP's: around 500 ps.

It's important to use the right medium for the job. Direct-attach copper cables have a maximum reach of around 7-10 m, depending on the devices being used, compared with a 300 m range for MMF fiber used above, and 10 km range for the SMF -- three orders of magnitude difference. This really only applies within a small footprint.

Conclusion

Direct attach copper cables have the edge over both SMF and MMF fiber when it comes to latency, and this is even more prominent for short cable runs because of the latency introduced by the SFP modules which drive the fiber.

If you really care about latency, (twinax) copper is faster than fiber.

Santa Clara—Corporate Headquarters
5453 Great America Parkway,
Santa Clara, CA 95054

Phone: +1-408-547-5500
Fax: +1-408-538-8920
Email: info@arista.com

Ireland—International Headquarters
3130 Atlantic Avenue
Westpark Business Campus
Shannon, Co. Clare
Ireland

Vancouver—R&D Office
9200 Glenlyon Pkwy, Unit 300
Burnaby, British Columbia
Canada V5J 5J8

San Francisco—R&D and Sales Office 1390
Market Street, Suite 800
San Francisco, CA 94102

India—R&D Office
Global Tech Park, Tower A & B, 11th Floor
Marathahalli Outer Ring Road
Devarabeesanahalli Village, Varthur Hobli
Bangalore, India 560103

Singapore—APAC Administrative Office
9 Temasek Boulevard
#29-01, Suntec Tower Two
Singapore 038989

Nashua—R&D Office
10 Tara Boulevard
Nashua, NH 03062