Ethernet PON Fiber Considerations

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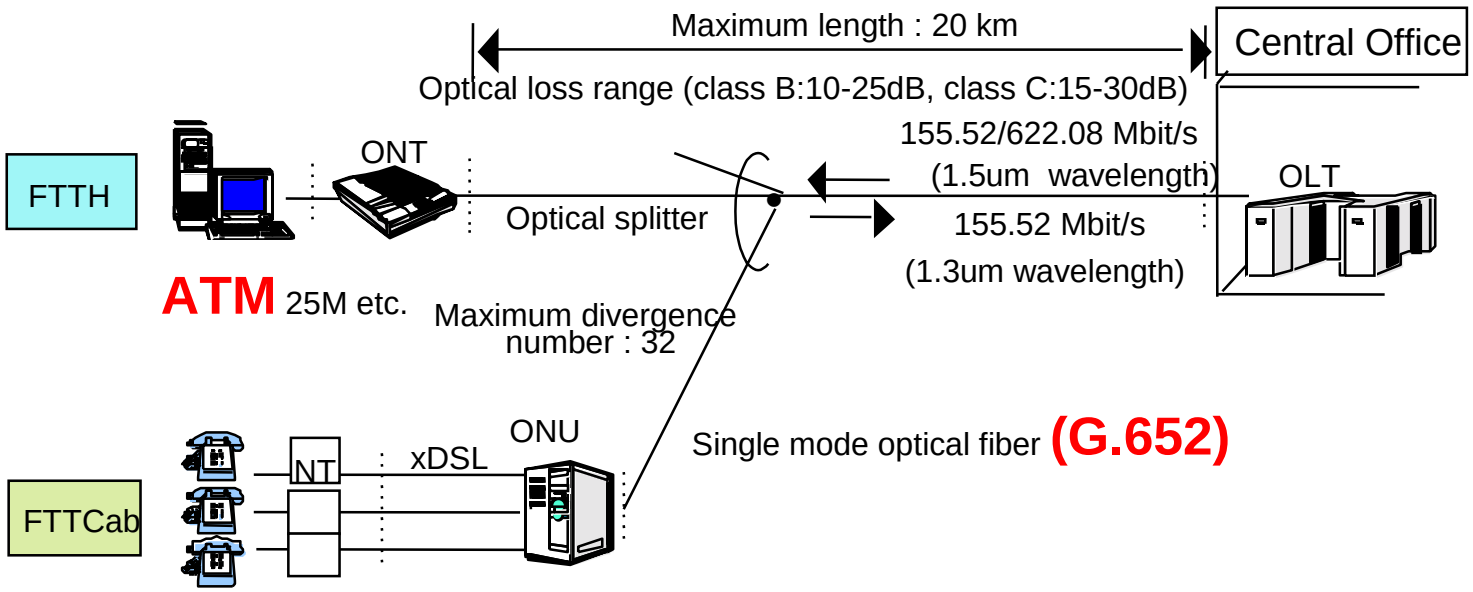
Outline

- FSAN/ITU Roadmap
- Good Ideas from ITU G.983.1 and G.983.3
- Opportunities for Improvement
- FP Link Budget Graphs
- Fibre Standards Recommendations from ITU
- FP Laser Spectra Considerations
- Summary

Outline of ATM-PON System Specifications (G.983.1)

These specifications apply both FTTH/B and FTTC/Cab and they are the only international standards in the world as high-speed optical access systems.



OLT : Optical Line Termination
ONT : Optical Network Termination

ONU : Optical Network Unit
NT : Network Termination

ITU-T Roadmap

	2001	2002	2003	2004 +
Data Rate Downstream (Mbps) Shared	155	622	622	1250
Data Rate Upstream (Mbps) Shared	155	622	622	1250
Wavelength Downstream (nm)	1490	1490	1490	1490
Wavelength Upstream (nm)	1310	1310	1310	1310
Max Reach from CO (km)	20	20	20	20
Split Ratio	32	32	32	64
WDM (wavelength allocation)	1260 -1360 US 1480-1500 DS 1539-1565 Enhancement Band G.983.3 Approved Apr '01			
Architecture	ATM-PON	ATM-PON	ATM-PON	GbPON
Dynamic BW Allocation G.983.dba (Efficient use of shared PON)	Expect Approval of Standard Dec '01			
Survivability (G.983.sur)	Expect Approval of Standard Dec '01			
OMCI (ONT Management and Control Interface)		Mar '02	Revision of G.983.2	
Video Overlay	1550-1560	1550-1560	1550-1560	1550-1560

Good Ideas from ITU G.983.1 and G.983.3

- Wavelength allocation
- 1 and 2 fiber specification
- Flexibility in architecture (FTTB, FTTC, FTTH, etc.)
- Scalability - “success based” capital
  - Balance investment vs. revenue
  - Flexibility of services provided
- Expanded temperature range
  - Outdoor ONU IEC 60721-3-4 w/ expanded environmental range (4.1E specified in ETS 300 019-1-4)
    - -45 to 45 degrees C *outside* air temperature

Environmental Conditions from Draft G.983.3

Table 5-a/G.983.wdm – Examples of environmental conditions

Applied example	Temperature (C)		Relative humidity (%)		Remarks
	Normal	Short term	Normal	Short term	
OLT	5 to 40	0 to 50 (Note1)	5 to 85	5 to 90 (Note1)	IEC 60721-3-3 class 3k3
Indoor ONU	–5 to 45	–	5 to 95	–	IEC 60721-3-3 class 3k5
Outdoor ONU (Note2)	-45 to 45 (Note3)	–	8 to 100	–	ETS 300 019-1-4 class 4.1E

NOTE1 – Option 1: short term refers to a period of not more than 72 consecutive hours and a total of not more than 15 days in one year.

Option 2: short term refers to a period of not more than 12 consecutive hours and a total of not more than four days in one year.

NOTE2: The environmental conditions for the ONU are environmental conditions outside the ONU enclosure, and assume that the ONU (including housing/cabinet) is provided by a single supplier and is located in a conventional indoor or outdoor setting. Environmental conditions for ONUs that are located in other settings (e.g., inside an operator-provided cabinet or a non-conditioned indoor environment such as an attic or garage) are for future study.

NOTE3: In many instances, network operators are willing to relax the low temperature requirement to –40 degree.

Opportunities for Improvement

- Only specifies G.652 type fiber
  - Splitter defines power budget
  - Limited upgradability with step index fiber
- Did not initially address video distribution
  - RF Video Overlay added in G.983.3
- ATM Transport only
  - In an ‘IP everywhere’ scenario Gigabit Ethernet can carry voice (VoIP), data and video (Web TV) on a single, simple, low cost, network infrastructure

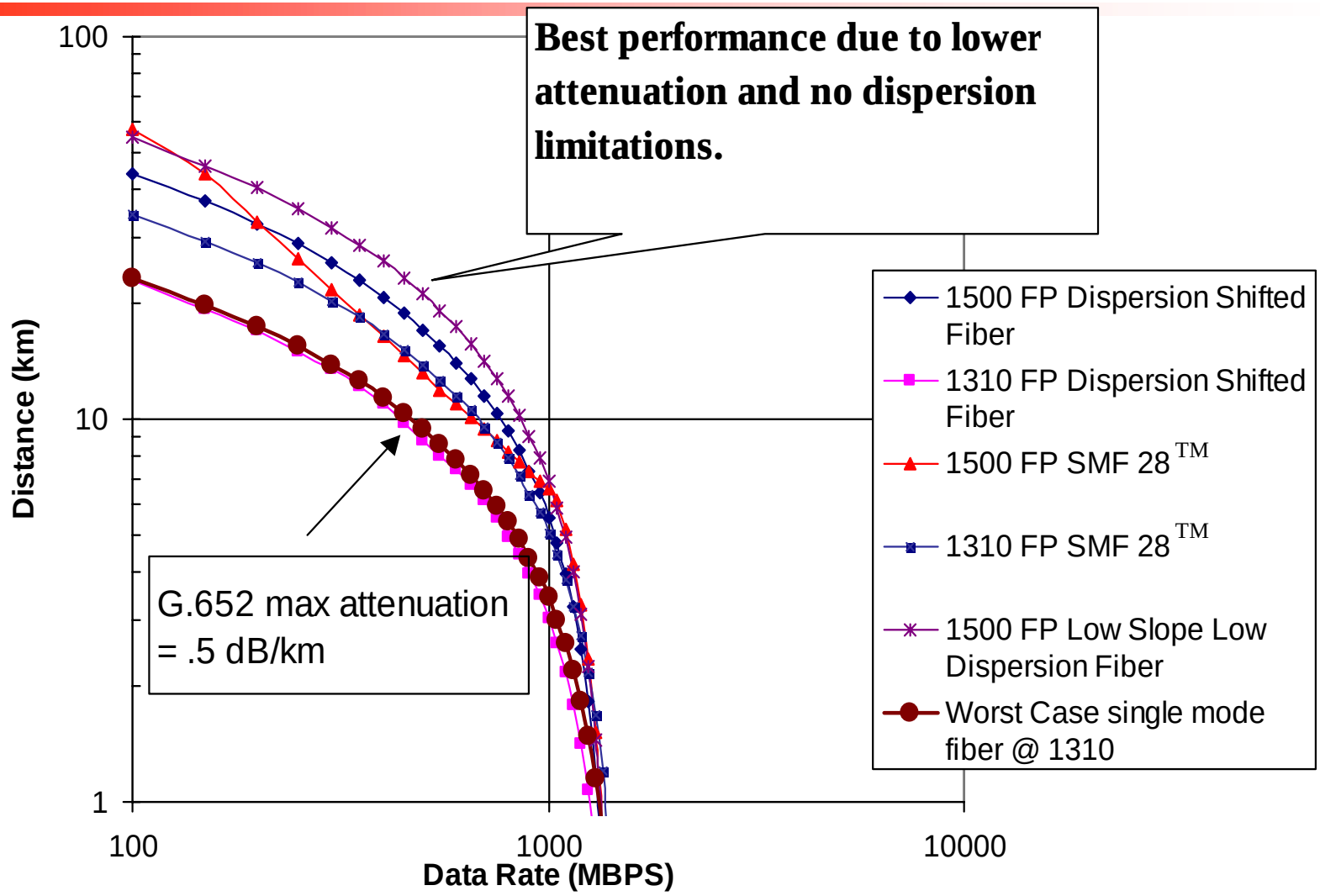
Study Group 9/Question 16 J.scm

"Optical amplifiers are used for compensation of optical transmission/splitter loss required for access networks. Dispersion compensation fibers are used for compensation of the chromatic dispersion of access network fibers. This fiber provides the reverse chromatic dispersion in advance in order to prevent degradation of CSO by transmission of 1.55μm optical signal over 1.3μm zero-dispersion access fibers."

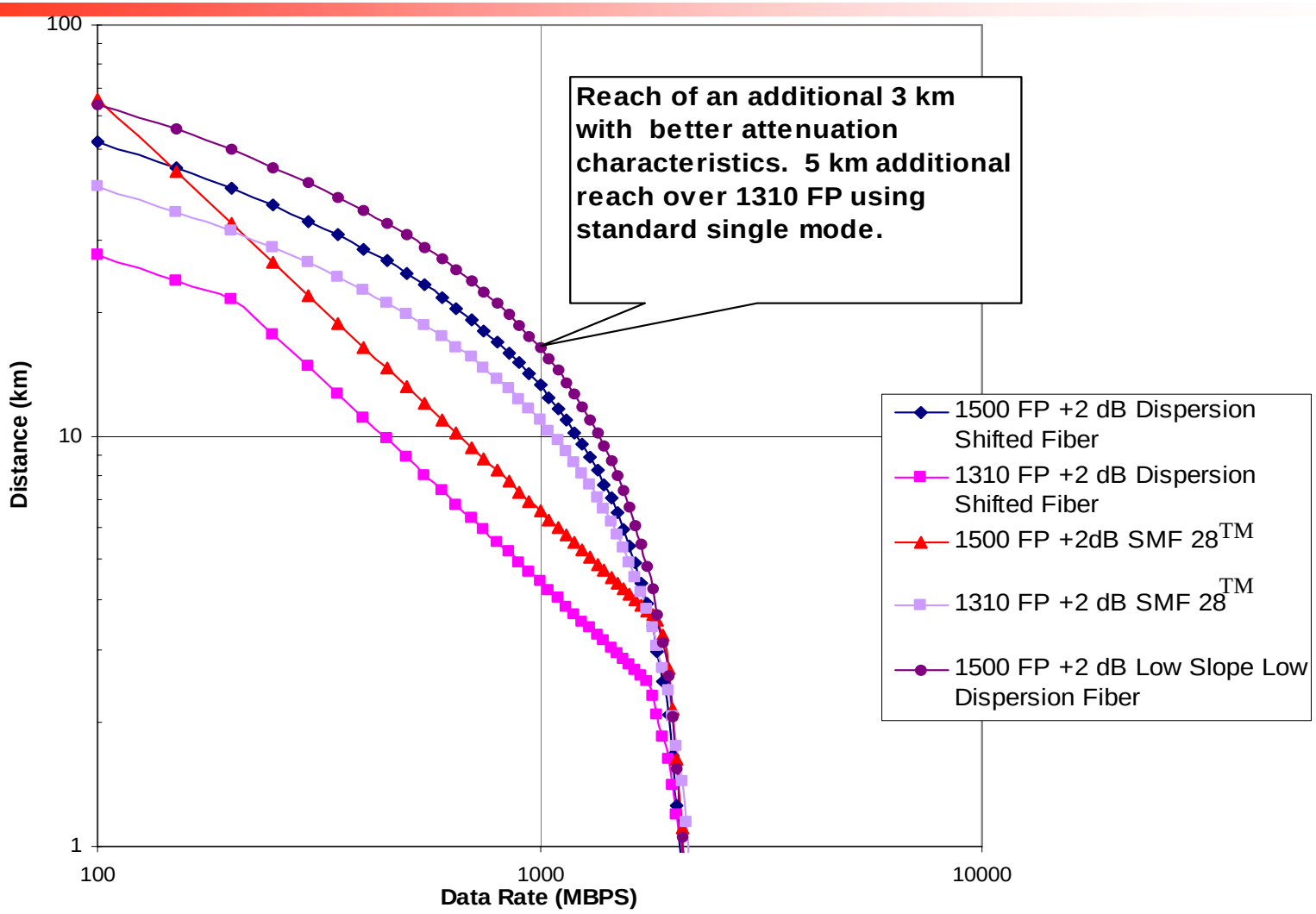
Link Budget Graph Assumptions

- Power Budget of 24 dB between TX and RX
  - Rx sensitivity of -24 dBm at 1 GBPS
  - 1 mW Laser source
  - BER 10^{-9}
- Fixed Losses of 22.5 dB
  - Splice losses (4 X .07dB): 0.28 dB
  - Connector Losses (3 X .75 + 3 X .5 dB): 3.75 dB
  - Splitter Loss: 14.45 dB
  - Link Margin 4 dB
- G.652 Fiber and Dispersion Shifted Fiber Attenuation and Dispersion Characteristics

FP Laser Data Rate vs. Distance



FP Laser Data Rate vs. Distance
Receiver Sensitivity -26 dBm



G.652.C Fibre Attributes

Attribute	Detail	Value
Mode field diameter	Wavelength	1 310 nm
	Range of nominal values	8.6-9.5 µm
	Tolerance	± 0.7 µm
Cladding Diameter	Nominal	125.0 µm
	Tolerance	± 1 µm
Core concentricity error	Maximum	0.8 µm
Cladding noncircularity	Maximum	2.0%
Cable cut-off wavelength	Maximum	1 260 nm
Macrobend loss	Radius	37.5 mm
	Number of turns	100
	Maximum at 1 550 nm	0.50 dB
	Maximum at 16XX* nm	0.50 dB
Proof stress	Minimum	0.69 GPa
Chromatic dispersion coefficient	λ_{0min}	1 300 nm
	λ_{0max}	1 324 nm
	S_{0max}	0.093 ps/nm^2•km
Uncabled fibre PMD coefficient	Maximum	** ps/√km

G.652.C Cable Attributes

Attribute	Detail	Value
Attenuation coefficient	Maximum at 1 310 nm	0.4 dB/km
	Maximum at yyyy nm ***	****
	Maximum at 1 550 nm	0.35 dB/km
	Maximum at 16XX* nm	0.4 dB/km
PMD coefficient	M	20 cables
	Q	0.01%
	Maximum PMD_Q	0.5 ps/√km

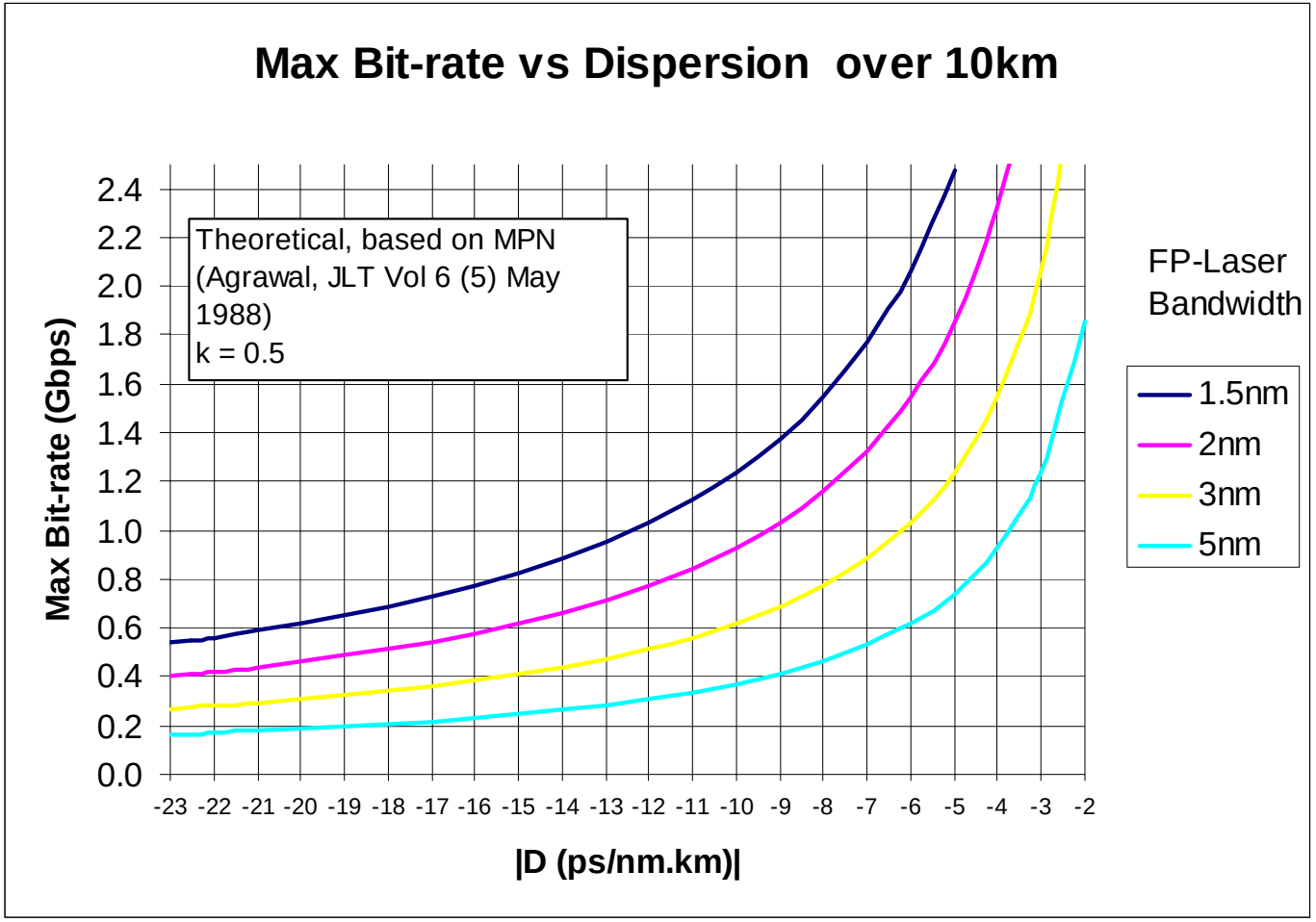
*** NOTE - The upper wavelength of this band has not been fully determined. However, XX is less than or equal to 25 nm.**

*****NOTE - The wavelength, yyyy, is recommended to be 1 383 nm ≤ yyyy ≤ 1 480 nm, and agreed between buyer and seller. If the water peak (1 383 nm), is specified, then both longer and shorter wavelengths may be used in the extended band. If the specified value is greater than the water peak, then only wavelengths greater than yyyy may be used in the extended band.**

******NOTE - The sampled attenuation average at yyyy nm shall be less than or equal to the value specified at 1 310 nm after hydrogen ageing according to IEC 60793-2 regarding the B1.3 fibre category (see also Appendix V [B.2]).**

Low Water Peak Specification

Maximum Bit-rate for a Given $\Delta\lambda$



$$B \leq [1/(\pi|D|L\Delta\lambda)].[\ln\{kQ/(kQ - 0.863)\}]^{0.5}$$

Summary

- Important to use the right fiber the first time!
  - Fiber can be engineered as part of total systems solution.
  - Include other ITU-T single mode standard specifications other than G.652 (example G.655, G.XXX for future use).
- Standard should help you engineer the links
  - Opportunities for fiber, electronics, and electro-optics to improve data rate, extend distance, and/or add overlay λ's for additional services/bandwidth.

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