

Derivation of Directness of Connection

The speed of light in fibre is roughly $0.66 \cdot c$ where c is the velocity of light in vacuum. The speed of light in a vacuum is 299,792.458km/sec exactly or roughly 300km/sec (to about 0.06% accuracy). Thus:

$$\text{RTD}[\text{km}] = \text{Alpha}'' * \text{min_RTT}[\text{msec}] * 200 [\text{km/msec}]$$

where RTD = Round Trip Distance. If we know the coordinates (latitude and longitude) of the source (monitoring host) and target (remote node) then we can obtain the RTD using the [Haversine formula](#) to calculate the great circle distance and double this to get the RTD. Note that the Haversine formula assumes the earth is a spheroid whereas it is an ellipsoid (6356.78 km at pole and 6378.14 km at equator) and this can give rise to errors of approximately 0.03%.

If we know the RTD and have measured the min_RTT then we can derive Alpha as:

$$\text{Alpha}'' = \text{RTD}[\text{km}] / (\text{min_RTT}[\text{msec}] * 200 [\text{km/msec}])$$

or since we normally think of the distance between the source and destination (D),

$$\text{Alpha} = D(\text{km}) / (\text{min_RTT}[\text{msec}] * 100 [\text{km/msec}])$$

Thus assuming no queuing (which is why we use min_RTT) and negligible network device delays: large values of Alpha close to one indicate a very direct path (i.e. a great circle route); smaller values usually indicate a very indirect path.

The approximations can mean that Alpha can be > 1 . Besides the approximation of the speed of light in vacuum and the Haversine approximation mentioned above, there is the approximation that the speed of light in fibre is $0.66c$. However if the refractive index of the fibre is 1.4 then the speed of light in the fibre is not 200,000km/sec but 214,000km/sec. For more on the refractive index see John E. Midwinter, "Optical Fibers for Transmission", John Wiley & Sons, NY, 1979. There it states:

For multimode and single mode step index fibers operating at wavelengths near 850 nm a typical cladding would have a refractive index of 1.518 and the core would have a refractive index of 1.538 which is 1.3% greater. The velocity of propagation in the multimode step index fiber would be near the speed of light (c) divided by 1.538.

For a refractive index of 1.538 then the velocity of light in the fibre = $0.650138 * c = 194,906.469 \text{ km/sec}$ or

$$\text{Alpha}' = D[\text{km}] / (\text{min_RTT}[\text{ms}] * 97.453235 [\text{km/msec}])$$

or Alpha' is roughly 2.6% $>$ Alpha, and $D' = \text{Alpha}' + \text{RTT} * 100$ is roughly 2.6% $>$ D.

Other causes for inaccuracies

- One likely cause for a large value of Alpha ($>> 1$) is that the min_RTT is "incorrect". For example the target host that is actually responding is not located at the specified lat/long. Often this is due to the target host being a proxy in an entirely different location.
- Another cause is that the lat/long for the target (or monitor) is inaccurate.