Derivation of Directness of Connection

The speed of light in fibre is roughly 0.66*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:

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RTD[km] = Alpha" * min_RTT[msec] * 200 [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:

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Alpha" = RTD[km] / (min_RTT[msec] * 200 [km/msec])
```

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

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Alpha = D(km) / (min_RTT[msec] * 100 [km/msec])
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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 vaccum 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 km/sec or

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Alpha' = D[km] / (min_RTT[ms] * 97.453235 [km/msec])
```

or Alpha' is roughly 2.6% > Alpha, and D' = Alpha' + 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.