Light Speed?

- Impact of propagation delay on latency

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Light Speed?

- Two factors impact latency for data transfer
  - The time packets spend in queues within the network
    - Impact of TCP congestion control algorithm
    - ECN to signal congestion before queues overflow
  - **The time packets spend propagating down the links between routers**
    - Speed at which light propagates through an optical fibre
    - Speed at which electrical signals propagate down a wire
    - Speed at which radio signals propagate through the air

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Reducing Propagation Delay (1/3)

- Physically shorter links have lower propagation delay
  - Significant reduction in latency by laying new cables that follow great circle routes between popular destinations
  - e.g., ocean floor cable from Japan to Europe via the north pole, rather than Pacific Ocean – US – Atlantic Ocean



https://www.scientificamerican.com/article/an-internet-cable-will-soon-cross-the-arctic-circle/

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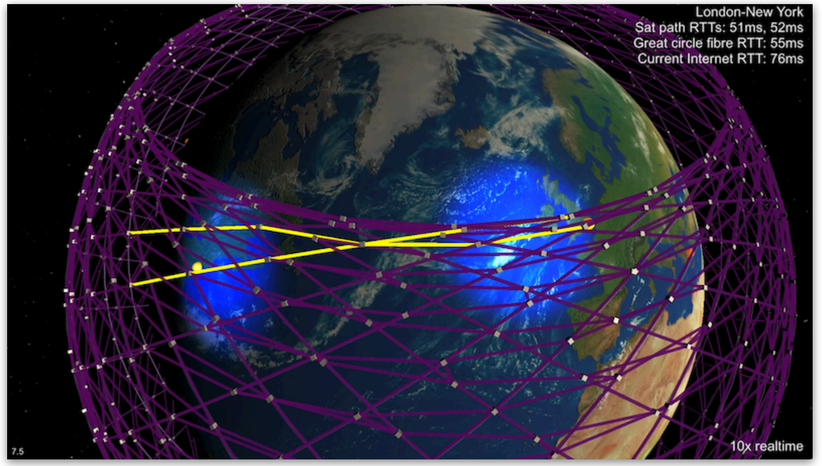
Reducing Propagation Delay (2/3)

- Signals propagate at the speed of light **in the transmission medium**
  - Speed of light in optical fibre ~200,000 km/s
  - Speed of light in vacuum 299,792 km/s
- SpaceX Starlink deploying ~4,000 low earth orbit communications satellites
  - ~47% reduction in latency since signals sent through vacuum rather than optical fibre
  - With careful routing, satellite path can follow close to the most direct great circle route



Source: Wikipedia



Source: Mark Handley

M. Handley, “Delay is Not an Option: Low Latency Routing in Space”, Proc. ACM HotNets ’18. https://doi.org/10.1145/3286062.3286075

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Reducing Propagation Delay (3/3)

- What application cares so much about reducing latency to spend $billions launching >4,000 satellites? Or new undersea cables? High frequency share trading

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Lowering Latency

- Latency due to queuing and propagation delays
- Queuing influenced by congestion control
- Propagation delays due to speed of light

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