Observations on Free Space Optical Networks

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Free space optical (FSO) networks support very high bandwidth while avoiding signal propagation infrastructure. They exceed the capacity of RF and are immune to RF interference but are susceptible to atmospheric interference. FSO nets are most useful when leveraging these properties, such as for space (inter-satellite and long range), emergency services (when fiber/cable is difficult to deploy), and last-mile connectivity (where fiber/cable is costly to deploy). FSO nets are also useful for very high density IoT deployments, beyond that supported by Bluetooth and at a lower power than WiFi.

There are significant challenges to each of these FSO net uses. Emergency services and last-mile are affected by atmospheric interference, which requires new approaches to agile re-provisioning and routing coupled with a high degree of multipath redundancy to achieve "five 9's" connectivity. Emergency services and IoT deployments require new approaches to automatic configuration and provisioning, which can be especially challenging for "long range" ground links (e.g., ~km), and involving advances in rapid pointing-and-tracking (PAT) technologies and rapid link "closure". All protocols and mechanisms at every layer need to be coordinated and designed for low-latency, e.g., using FEC coding with very wide bandwidth rather than independent parallel low-rate coding that can add substantial channel delay, or considering concurrent multipath methods that consume (and thus trade) bandwidth for latency. Finally, FSO networks require support for native digital optical processing to enable advanced network functions such as channel aggregation and de-aggregation, packet processing, big data filtering, and network security, while also avoiding costly and complex OEO and OOO conversion. Optical wave mixing of phase-encoded signals is a viable approach, but recent advances in guided digital processing computation will need to be adapted to free-space use, potentially using plasmonic devices.