NSF Future FSO Network Focus Areas

As was learned from the DARPA FOENEX multi-node FSO networking experiments there are a number of significant challenges in developing a robust networked communications network with FSO. The DARPA FOENEX network router and FSO system had demonstrated that mobile and fixed multi-node networks of FSO systems was possible. Reaction to link and network disruption events including atmospheric scintillation, fog/clouds, and platform and terrain obscuration was demonstrated. Some of the challenges experienced are unique to mobile FSO terminals but most also apply to fixed networks as well. The following challenges could be used are starting points for exploring new solutions.

1. Link quality and outage prediction techniques and network topology decision making. The decision to make a topology change is a significant reaction to link and overall network quality according to some criteria. Each topology change can have significant packet loss due to FSO data rates and the resulting topology must be determined to be a better decision for the local link or overall network quality. In DARPA FOENEX a simple FSO data rate sampling mechanism was used to determine link quality and a centralized topology manager used various inputs, like aircraft position, antenna placement and shadow graphs, DTED data, and air and ground positioning to make topology decisions. The only predictive techniques were focused on outages due to blockages. Predictive techniques should be investigated that give much better accuracy in assessing when a topology change should be performed due to atmospheric conditions while considering the local link and network-wide costs associated with the decision.
2. Application of new processing techniques and algorithms for reduced complexity and cost of FSO networking processing. In order to mitigate packet loss at 10Gbps FSO data rates the DARPA FOENEX program utilized custom networking hardware and software solutions. As data rates increase this approach gets more costly and complex. Processing was partitioned amongst off-the-shelf CPUs and FPGAs with data plane processing and link outage detection in hardware and control plane in software. Since the DARPA FOENEX effort there have been many advances in processing and memory architectures that could be studied and leveraged in defining the architecture for a simpler, most cost effective, and scalable FSO networking solution.
3. Scaling FSO networks to 10s and 100s of nodes. DARPA FOENEX demonstrated a very modest number of network nodes and techniques for mitigating link disruptions. What topology management challenges exist when we scale such networks to 10s or 100s of networked FSO nodes? Are the challenges the same for fixed versus mobile? What topology decisions need to be made when the networks consist of space, ground, mobile, and underwater FSO nodes? If FSO nodes can transition to be as pervasive as RF network nodes what solutions must exist to meet these challenges?