

## Domain of Problem Spaces

- Data Center
  - Get rid of fiber
  - Reliability
  - Support multicasting
  - Energy efficiency
- In-room / VLC
  - Does hybrid FSO/MMW solution make sense?
  - Precision positioning
  - Low power & high density of objects
  - Security for signal containment & intrusion jamming (eavesdropping)
  - Interference immunity
- Reach 100m & 1000m
  - High availability vs. low availability
  - Disaster-caused fiber outage
  - Space diversity can offer better capacity than radio
  - Link capacity over 100Gbps, no other solution exists besides FSO
  - Limited power deployment
  - Security – hard to intercept
  - Robust against interference
  - No spectrum license & cost

## Use Cases & Applications

- Mobile terminal (V2x)
  - Combine Lidar with FSO communication for V2x
  - Video streaming for safety in the road for cars and pedestrian
  - Inventory of moving parts in warehouse, robots in grocery stores stacking up products on the shelf+-
- Underwater
  - Increase range
  - Increase data rate
  - Location information
  - Underwater to shore
  - Cable replacement (rocks at the bottom of the ocean may not permit cable use)
- 5G backhaul – spectrum management, obstacle locations
  - 5x9 is required
  - Be mindful of E-Band is the competing technology, and fiber
  - RF spectrum license entry barrier

## Research Issues

- Last mile multi-Gbps connectivity with network – FTTX replacement
- Indoor high data rate (IoT)
- Emergency response (fiber is cut – rapid replacement)
- Underwater & Air2Underwater (e.g., harbor safety)
- Short range backhaul (100m)
- Backplane of the rack (1m range)
- Intra satellite communications
- Fast link reconfiguration

## Research Issues

- Spatial MIMO/diversity (channel parallelism)
- Subnet routing & repositioning
- Improving PAT
  - Simpler
  - Faster
  - More stable
  - Special use cases
- Integration with existing infrastructure
  - As seamless as possible with higher layers
  - Redesigning upper layer functionalities/protocols
    - Entire protocol stack is not designed to work with FSO typical channel behavior

## Research Issues

- Design for latency (interleaving bits vs. path diversity and if possible, proactively prepare for handover)
- Design for security
- Ultra low power FSO for IoT & diffuse links
- Indoor precise positioning
- Multi-element FSO solution
- Use FSO to take load off RF solutions
- Flexible opto-electronics
- FSO Latency must be improved
- Authentication time in FSO must be reduced
- Security and privacy must be addressed
- Medium-to-high availability Internet access for rural areas, connectivity to rural and remote areas (drones, aerostatic balloons)
- Cross-links for HAPs (as opposed to between satellites, etc. that the long range group is presenting)
- FSO for chip-to-chip communication