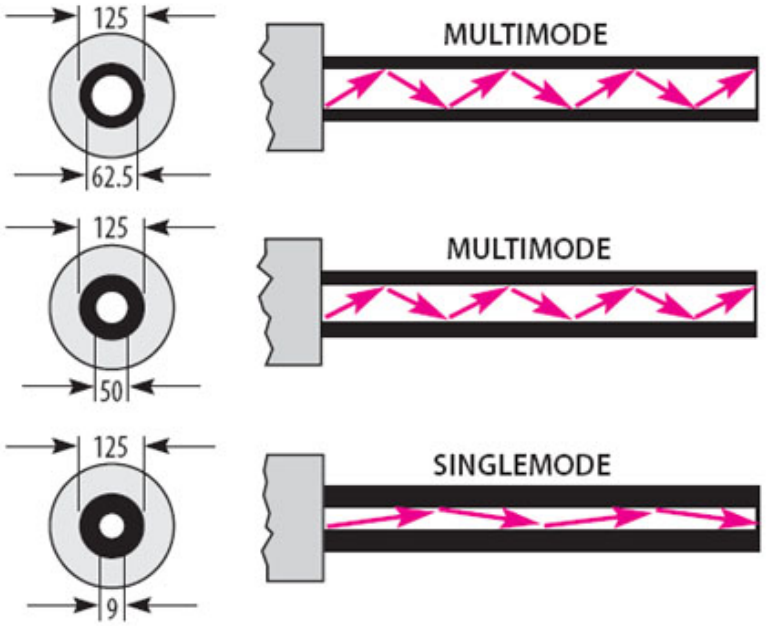
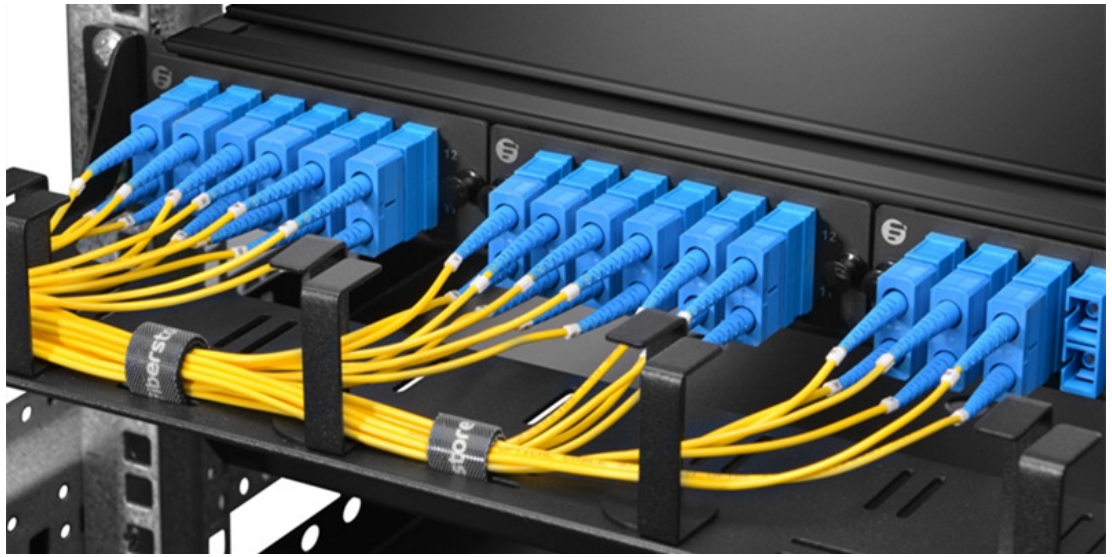
Using Power and Fiber at the Cyber Kinetic Environment

Trying to clarify needs for RFP

Fiber and Networks

- Lets talk about fiber!





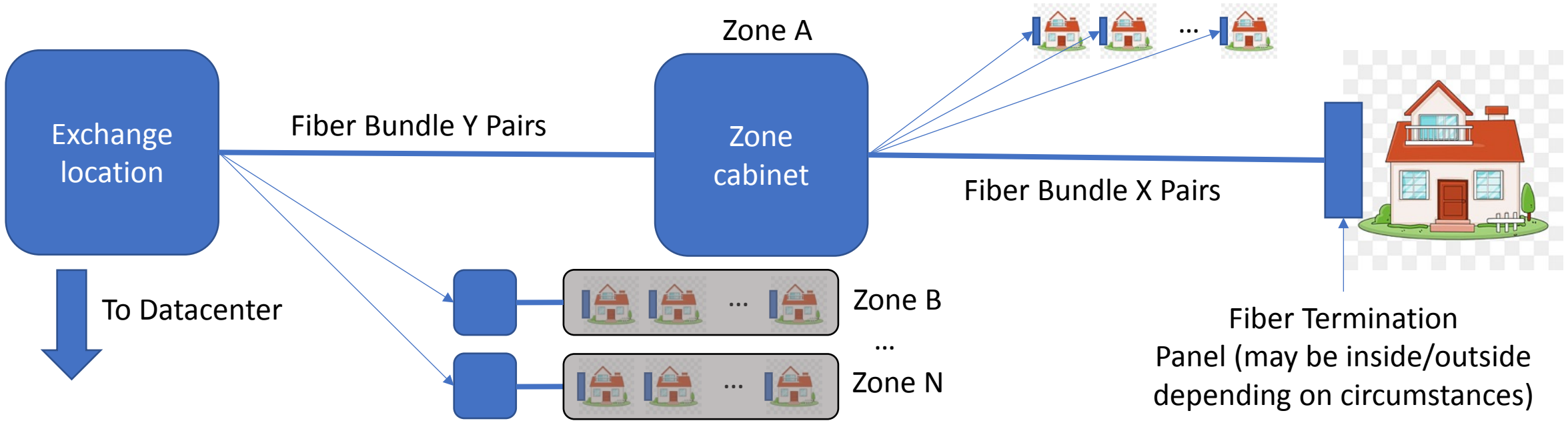
One of these things is not like the others…

Fiber (and other comms) in the CKE

- We want to be able to “hook up a bunch of stuff” to an (mostly) Internet Protocol (IP) based network
  - Use “active optical” point to point connections for high bandwidth needs over Ethernet. Standard datacenter protocols/framing and speeds. 100+ Gbit/sec symmetric
  - Use “passive” multi point to point connections for a large number of “low bandwidth” needs. XGS-PON framing (convert to Ethernet on both ends) 10 Gbit/sec symmetric shared by some number of devices.
- Why do we want this?
  - Carry data from sensors and devices to processing/storage
  - Carry Command and Control signals to/from sensors and devices (customer oriented)
  - Carry C2/management signals to/from all network equipment (environment operator oriented)
- Key enablers
  - Physical separation of certain capabilities (management from data)
  - Fiber strands can be changed from active to passive as need arises
  - Every location with service will have X strands (need to determine X)
  - Needs to be future proof to 400+Gbit/sec per pair (active) to many kilometers distance

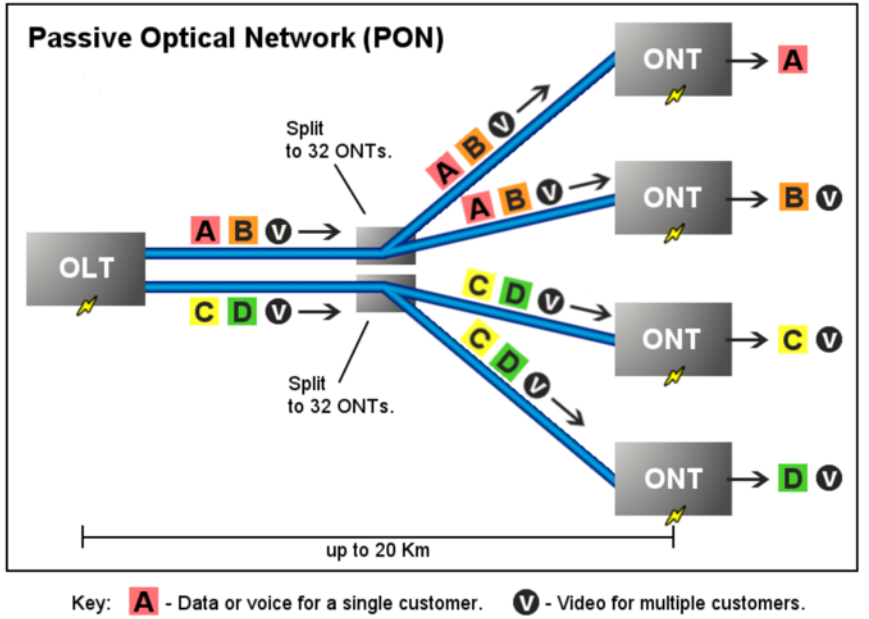
Fiber network - layout concept

- How to stage stage the install? How to best work the “active” distribution side of things. Passive is straight forward.
- Current vision, but better engineering may say a different approach is best
  - Some number of “end points” where service terminates (houses, airfield, towers, etc.)
  - “minor zone cabinets” scattered around the field lab as needed, endpoints connect to minor cabinets
  - Major home location where all the minor cabinets connect to a central location. Will then patch this location to the data center (allows the data center to move in the future)



Fiber network - Passive vs Active at network layer

- Passive: Carry more devices on less fiber
  - No matter how much money we spend, we will always have a “pair budget”
  - Passive Optical Network (PON) allows us to share a single pair/strand among many endpoints. Especially useful to conserve fiber from “home” to “zone cabinets”
  - Lower power budget
  - XG-PON or XGS-PON possibly 10G-EPON (reduces overhead keeps native Ethernet)
  - 10Gbit/sec shared among 16, 32 or 64 endpoints
  - Can provide many network services outside of IP (Plain old telephone, CATV, analog telemetry, etc.)
- Active: (we mean active Ethernet here) carry more bandwidth
  - Sharing of an active link is a function of endpoint devices (ethernet switches) not network hookup (which is how passive shares fiber). Sharing is at the “packet layer”.
  - Will start at 10Gbit/sec and will bond multiple links if more bandwidth is needed. Can easily support 40Gbit/sec with end equipment upgrades. Will upgrade to 400Gbit/sec when technology prices come down.
  - Very familiar to datacenter and IT folks



Fiber network - Passive vs Active at termination

- Passive – One Optical Network Terminal per connection. May use several ONT per physical location to handle “separate channels” the ONT provides a standard copper gigabit ethernet RJ45 connection.
- Active – Uses an Ethernet switch with SFP+/QSFP connectors and optics.

Fiber Termination Panel (may be inside/outside depending on circumstances)

Ethernet to “end” network

Also other protocols possible

Fiber Patches from termination to ONT

Ethernet to “end” network

Fiber Patches from termination to switch

Fiber network - Passive vs Active at initiation

- Passive: Run at least 40Gbit/sec Ethernet to the PON cabinet
  - PON cabinet has cards to put in SFP+ optics to provide service to cabinet, which then lights passive strands
- Active: Run at least 100Gbit/sec Ethernet to the “main feeder” switch fabric
  - Main feeder has many SFP+/QSFP ports/optics to light active pairs

Passive equipment

Active equipment

Big fiber bundle

Mix/match cross patch
Active passive as needed

Medium fiber bundle to each zone cabinet

Zone cabinet

Small fiber bundle to each endpoint

Datacenter

Exchange location

Fiber Layout – Remember this is a Research Tool *not* a standard utility

- Fiber will be laid out through out the town and outlying towers or other infrastructure of interest
  - Skeet, Pool, Water Tank, Comm towers, airfield
  - Observation tower
  - All the current town center buildings, and other ancillary facilities
  - IOT houses present/future
  - Add more than standard “pull boxes” and ensure that plenty of slack exists to allow branches to be created if desired
  - Ensure that empty “inner duct” is run to facilitate future expansion
  - At all road/grade crossings put pull boxes on each side to allow for termination of “smart city” equipment
  - This thing must be easily expandable and reconfigurable to support future experiments
- All locations should have ability to be services either by passive or active as needed to support experiment objectives
- See following slides

Phases of work

- This mostly just notional to provide insights into our thinking
  - In the power laydown we can phase the install based on the logical breakdown of the power grid (distribution, transmission, generation)
  - You need the “main exchange” and at least 1 “minor zone cabinet” end to end in order for anything be useful, but if you have geographically disperse endpoint needs you may need all the zone cabinets up front
- Proposed plan
  - Develop an our best understanding of all the desired “endpoints” and rank order them as to priority
  - Use the priority to determine where we need intermediate cabinets both now and for future phases

Fiber network – closing thoughts

- Critical design decision: minimum number of pairs to each endpoint
  - Influenced by the design of the networks that ride “on top” of the fiber
  - Influenced by the number of physically separate networks we want
  - Influenced by the network operations model we embrace
- Critical design decision: automate cross patching at the exchange and zone cabinet locations
  - Influenced by the requirement to have completely physically separated physical network layer
  - All optical switching (which would ensure such separation) is quite expensive