A proposal design for detection unit data transmission system on copper backbone

Summary

- Considerations pushing toward a copper backbone
- Schemes of Detection Unit links
- Current optical solution in Nemo
- Proposed optical-copper solution
  - possible implementations
- Conclusions

GENERAL CONSIDERATIONS

- "Lessons learnt" from the integration of NEMO tower
- DC power distribution available at the Capo Passero site
- The technological progress in the data transmission field

convinced us to explore a simpler way to realize the data transport inside the NEMO tower in order to simplify:

- backbone integration and handling;
- power and costs;
- cables and connectors.

Fiber Backbone assembly

DU communication links

- The DU connection to on-shore must be optical:
  - distance is about 100 km
  - aggregate data rate from floors is high (~Gb/s)
- The DU backbone can be either optical or electrical
  - link are tens or hundreds of meters long
  - data rate can be as small as 100 Mb/s

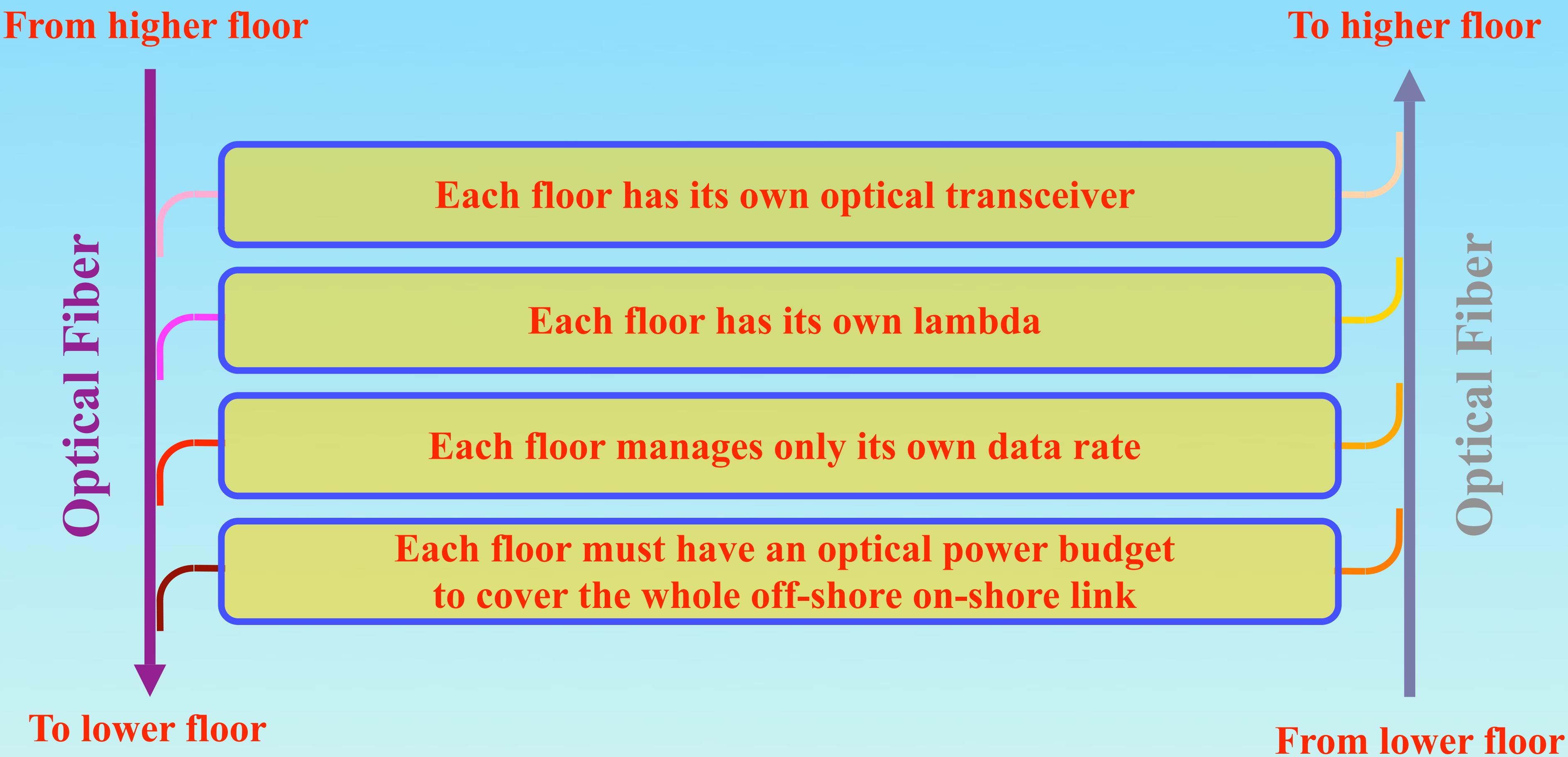
all-optical solution

- long haul: fiber
- DU backbone: fiber

hybrid solution

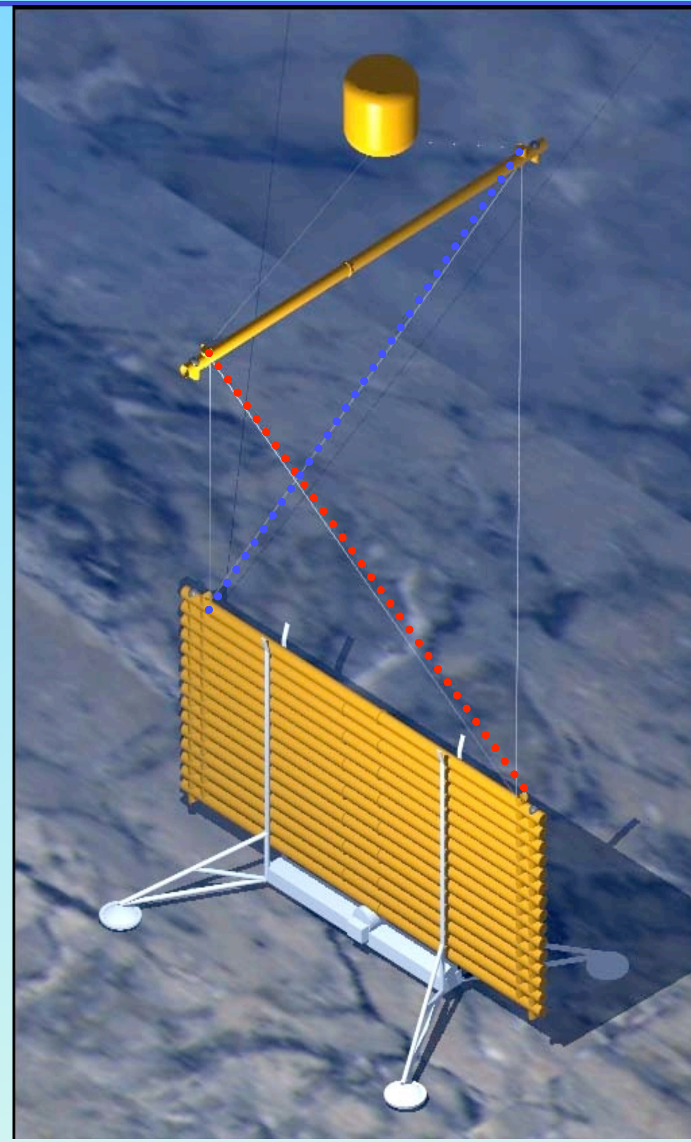
- long haul: fiber
- DU backbone: copper

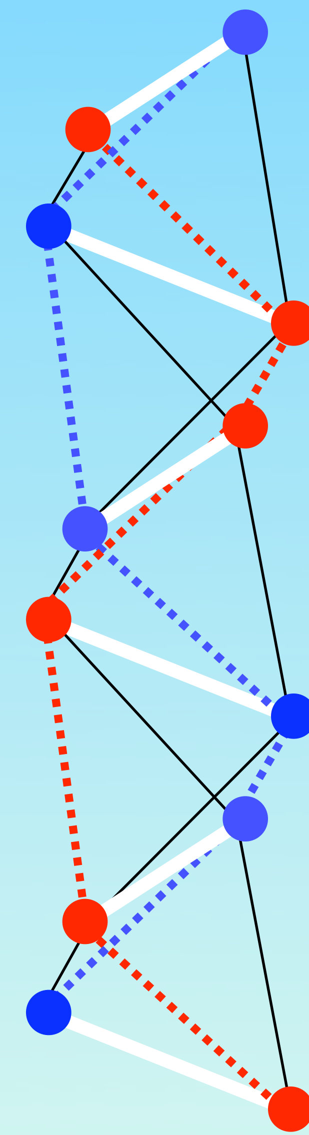
Current Optical Solution: Backbone Add & Drop based



Tower Layout

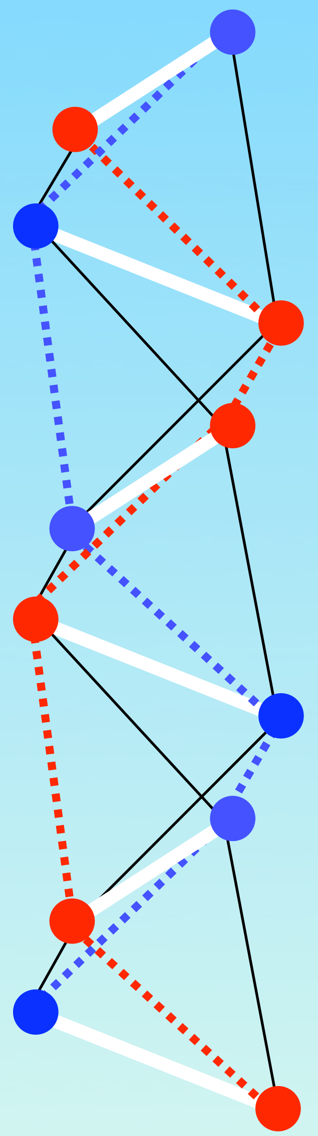
Two contiguous arms of a NEMO Tower (40 m far apart) define an isosceles tetrahedron whose short and long sides are 20 m and 42.4 m long respectively.
Therefore any two vertices of adjoining floors are 42.4 m apart (about 50 m).



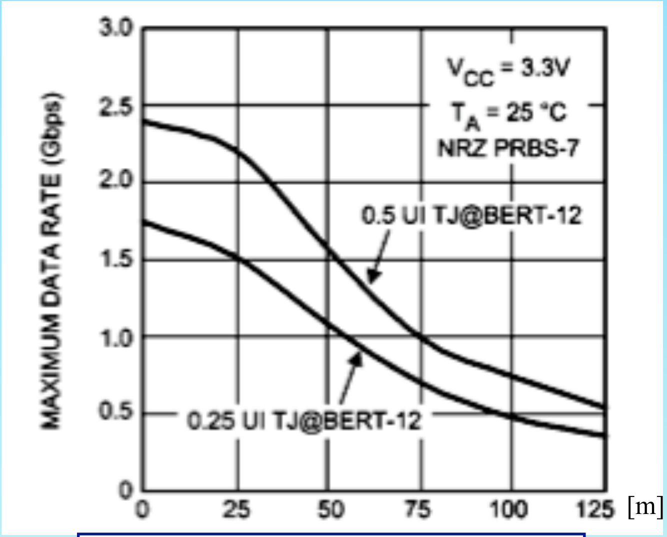


Copper Link Highlights

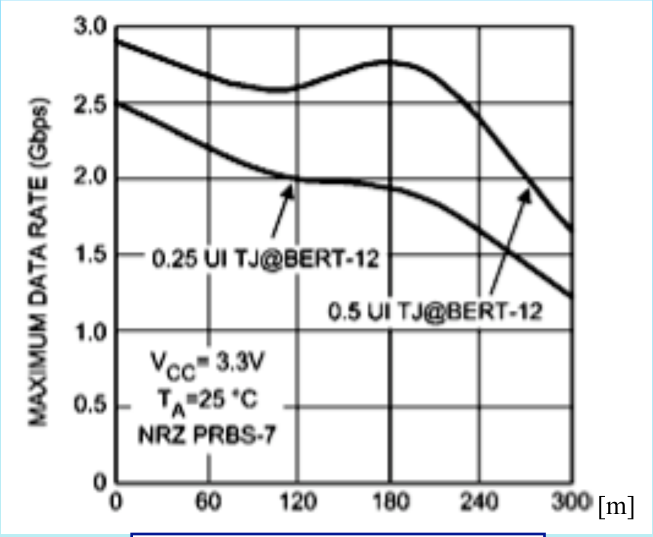
- Constraints:
  - suited Twisted Pair or Coax cable
  - length of a single hop (~50m)
  - max data rate of a copper chain (~1.25 Gb/s)
- Copper Node Features:
  - the chain is synchronous
  - auto-identification of nodes
  - payload can be dynamically allocated
  - the node is designed as a plug-in module which can be seen as a "transceiver" by a host board
  - each node is reprogrammable
  - node power consumption is very low (~3W)



Data Rate vs. Length based on selected chipset

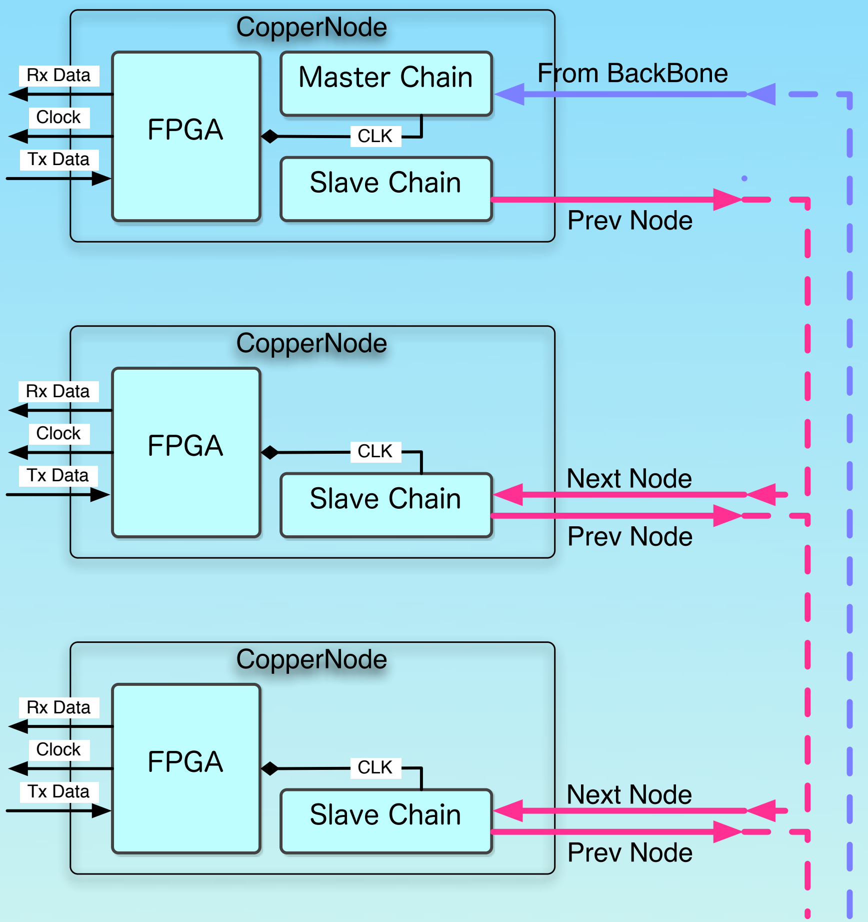


Twisted pair cable



Coaxial cables

“WaterFall” Scheme



The link is “ring-like” with asymmetric data rates:

- The timing and control link @ 20 Mb/s reaches only the top node.
- From top a daisy chain link @ 1.25 Gb/s for data and control

Pros

- Simple UpLink
- Low Power
- Less Connections

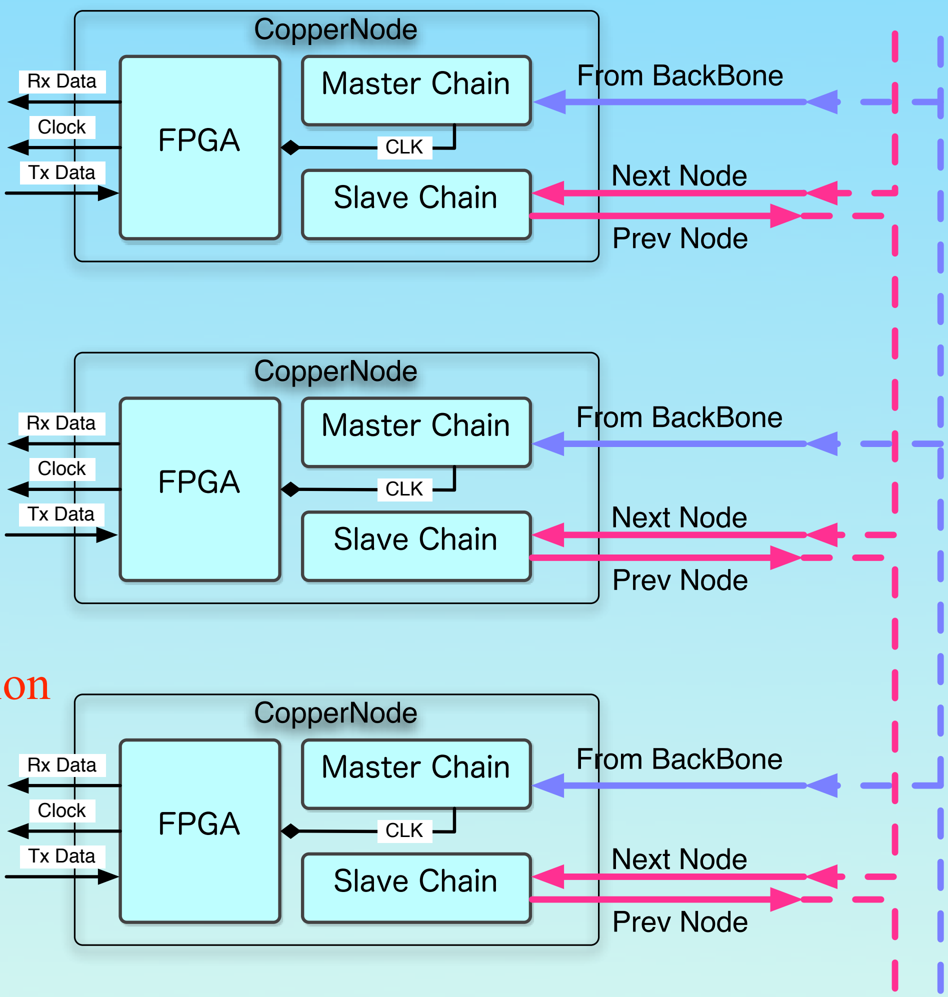
Cons

- Timing from High Speed
- Single Point Failure
- Complicate Protocol

Multi-Tap Scheme

Each node extracts data from the timing and control link:

- Up-going timing and control link @ 20 Mb/s
- Down-going daisy chain link @ 1.25 Gb/s for data and control



Pros

- Timing from Low Speed
- Simple UpLink
- Medium Power

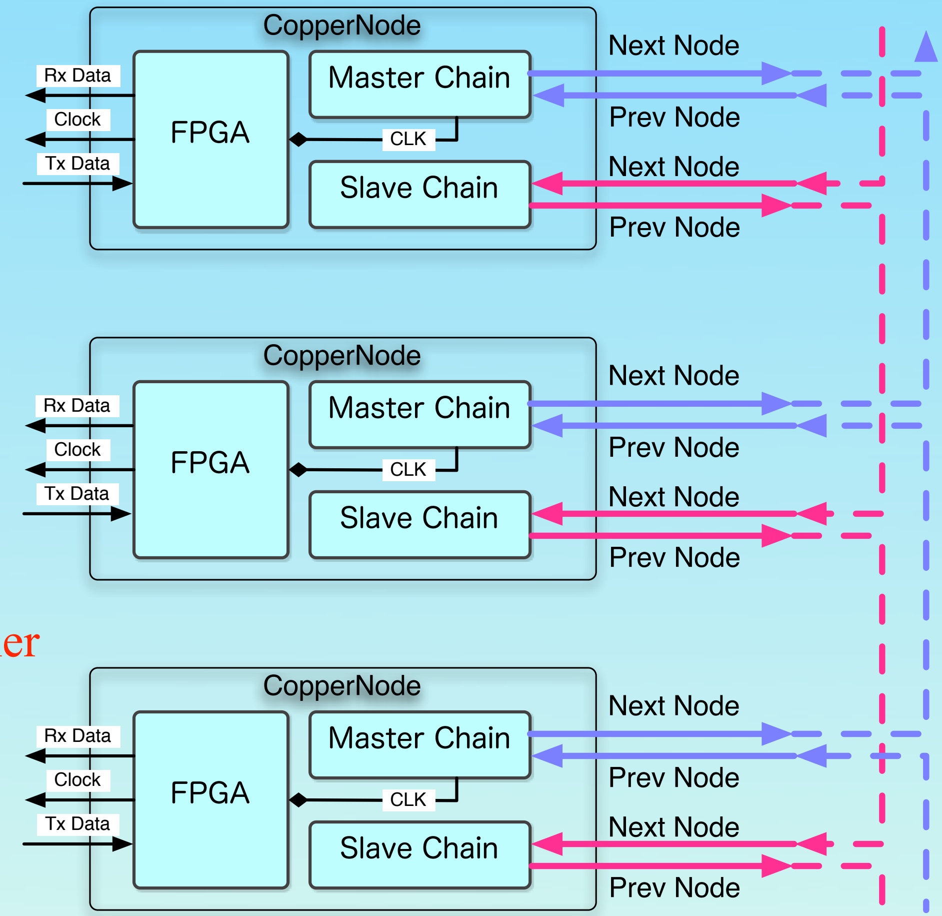
Cons

- Hard implementation
- Not scalable

Full Daisy Chain Scheme

The link is bidirectional with asymmetric data rates:

- Up-going link up to 200 Mb/s for timing and slow control
- Down-going link @1.25 Gb/s for physics data and control



Pros

- Higher up-going speed
- Nodes are identical

Cons

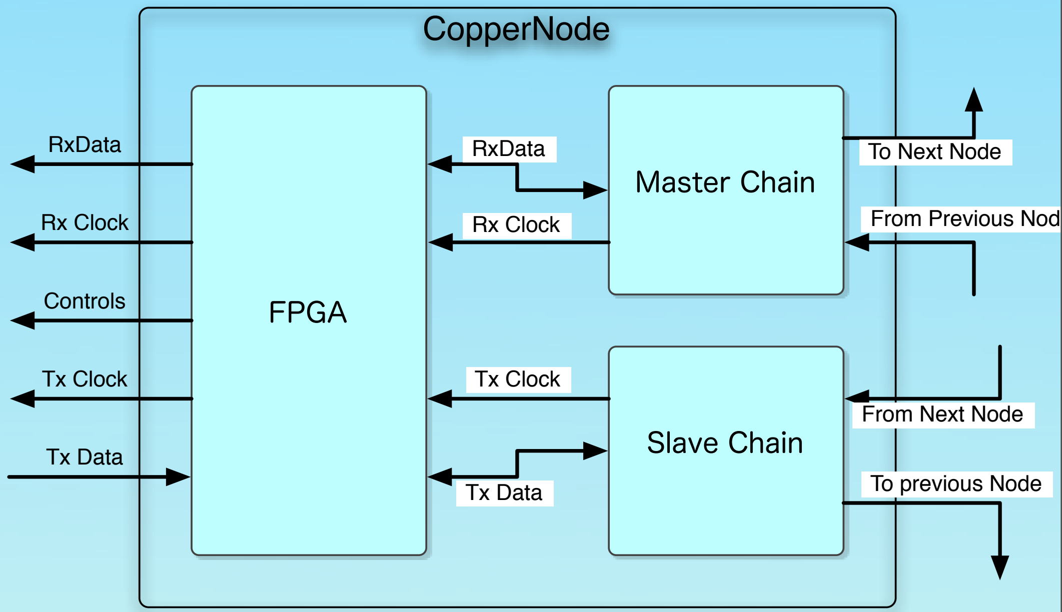
- Higher Power
- Failure stops higher floors

Trading more backbones for reliability

- Multiple Backbones means redundancy and an increase in power, cost, complexity;
- Reducing the number of PMs per backbone reduces the overall rate increasing hop length: single storey failure could be sectioned out!
- DU JB must mux-demux multiple backbones;
- DU JB must contain electronics to bridge copper and fiber.
- An independent communication line is dedicated to power management, backbone sectioning (in case of failure), and slow control functions (see A. Orlando presentation) over a single twisted pair.

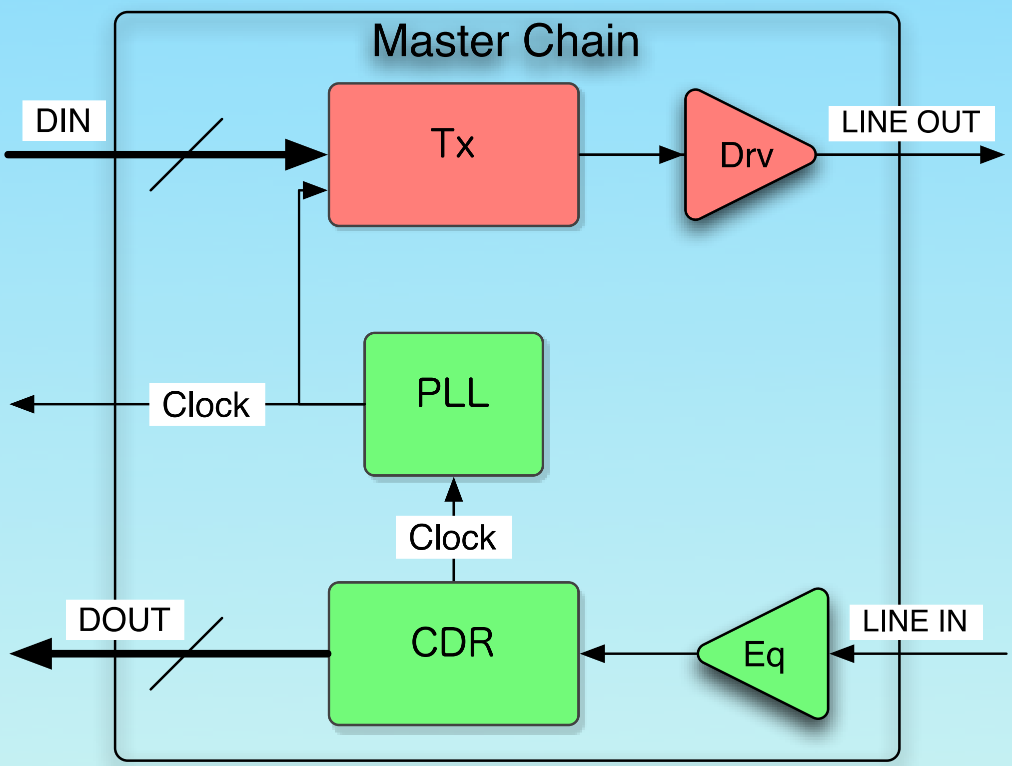
Copper Node Block Diagram

- pluggable mezzanine board
- stand-alone for debug
- interface SerDes-like
- no user intervention for PHY management
- reprogrammable on-the-fly
- dynamic allocation of payload



Master Chain Implementation

- Rx Line equalization;
- Rx clock&data recovery;
- Jitter cleaning PLL;
- Tx @ same Rx rate;
- Tx Line driver



Concluding Remarks: hardware

- Only one electro-optical transceiver per tower instead of 16 (less power and money).
- Less wavelengths simplify the underwater optical network and reduce fiber count.
- Simple and robust backbone made with identical 50 m long tracts.
- Simple mechanics and connectors.
- A procedure for node-to-node timing calibration is under development.
- The study of cable and connectors impact on performance can be evaluated separately.

Concluding Remarks: software

- Copper transmission at high rate over long distance is based on emerging but proven and existing technology.
- Dynamical bandwidth allocation allows complete chain flexibility and reconfigurability.
- All the backbone communication burden (bandwidth negotiation, etc.) is user transparent.
- Tower rate compatible with PCIe throughput (for on-shore receiving).
- All data of a tower on a single host.