Data Transmission system based on copper and fibers

Summary

- DU communication strategy
- All-fiber approach
  - Current Nemo solution
- Hybrid approach
  - Copper Link requirements
  - Link implementation
  - Complete Copper Node block diagram
  - Reduced Copper Node block diagram
  - Mezzanine design
    - Board form factor
- Conclusions

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

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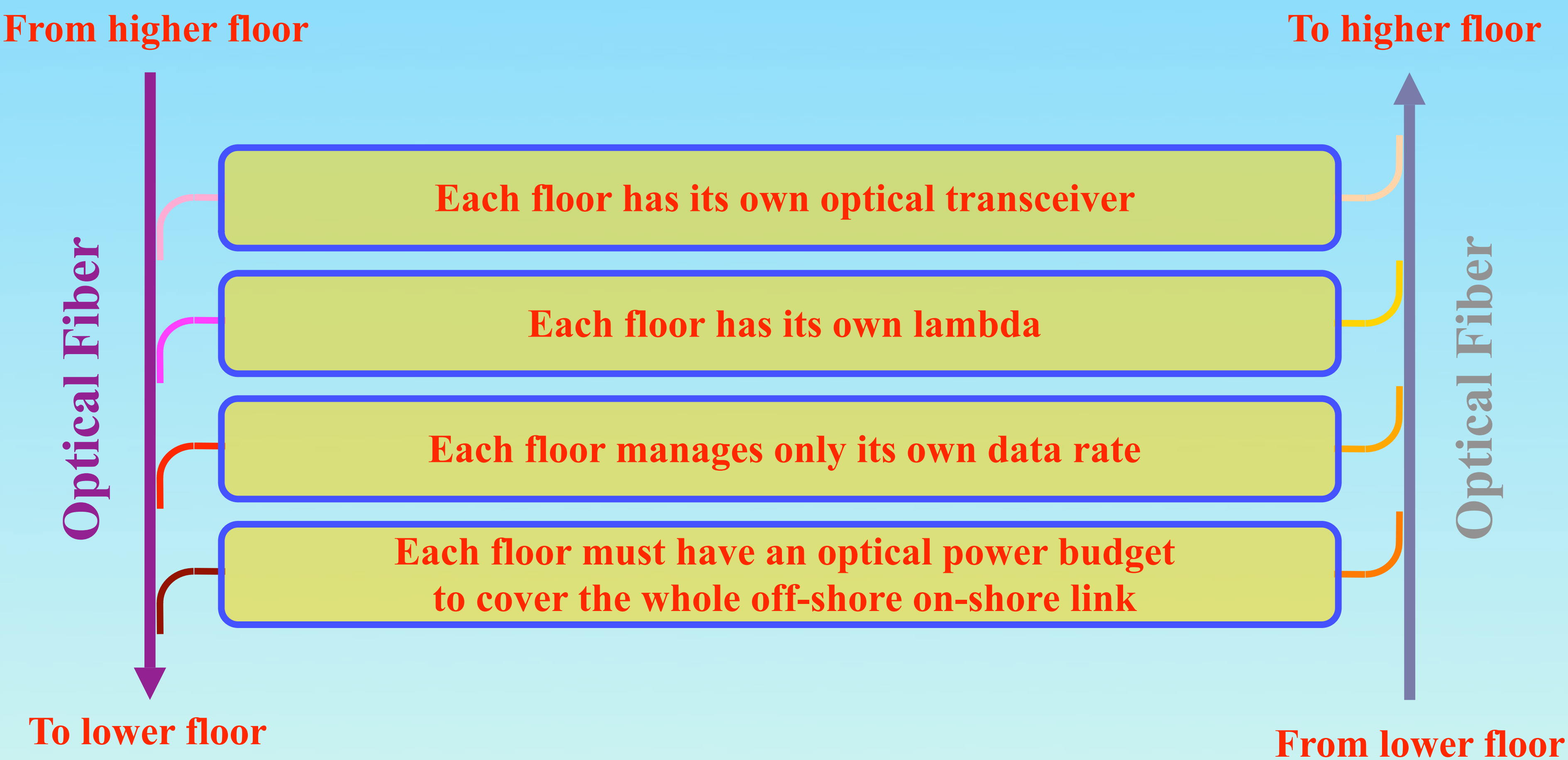
Current solution: optical backbone Add & Drop based



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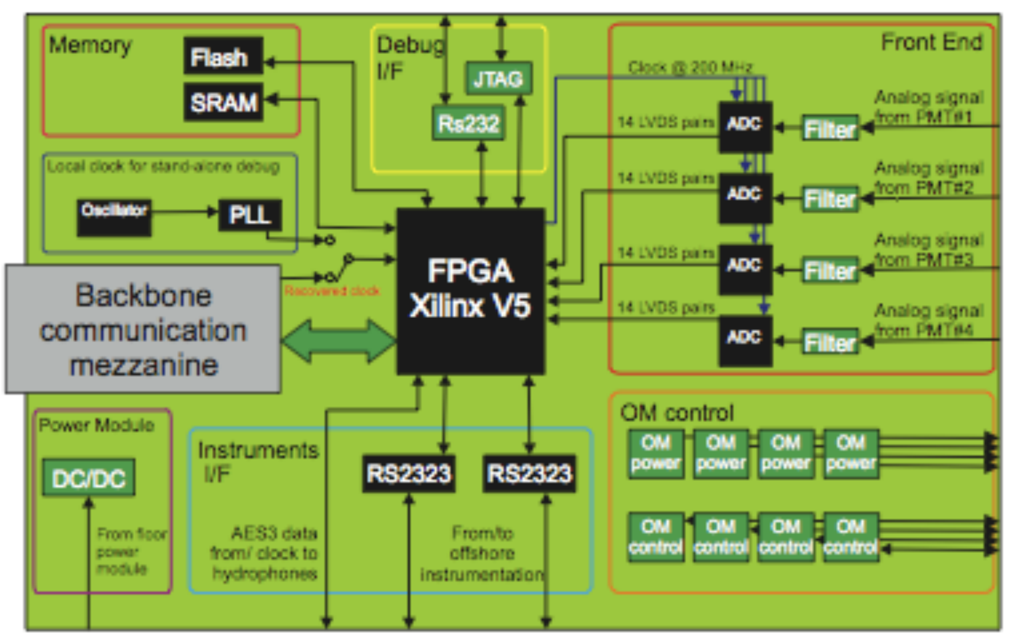
New generation of Nemo storey electronics

- Integrated readout
- Environment instrumentation interface
- communication mezzanine (Nemo-like)



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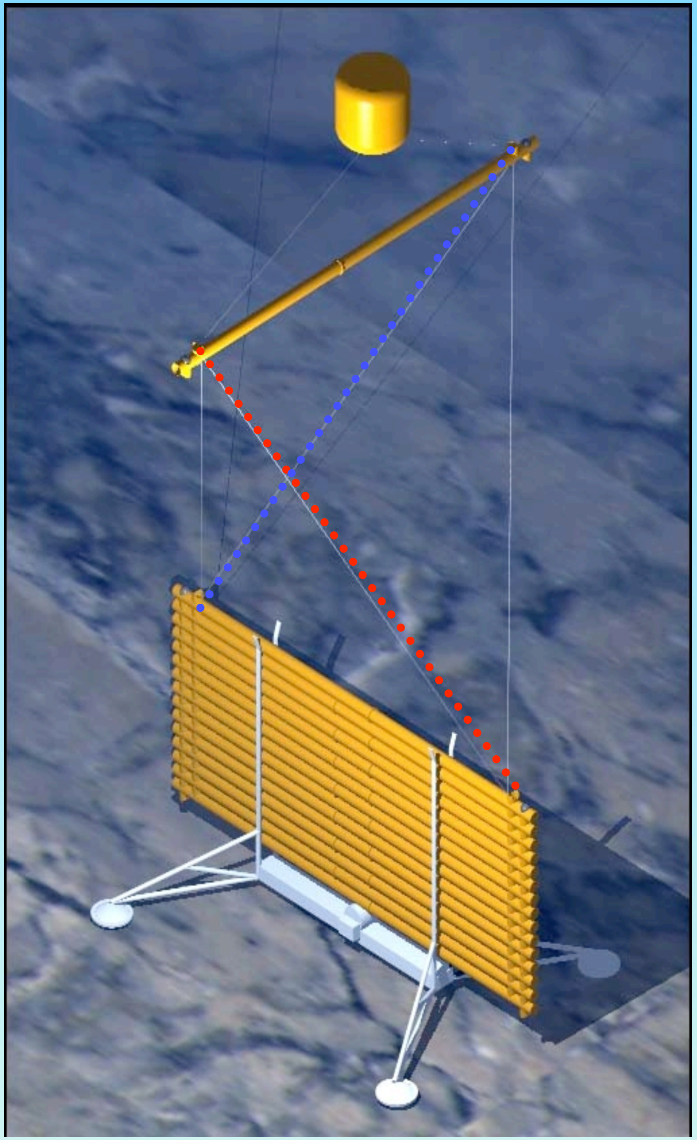
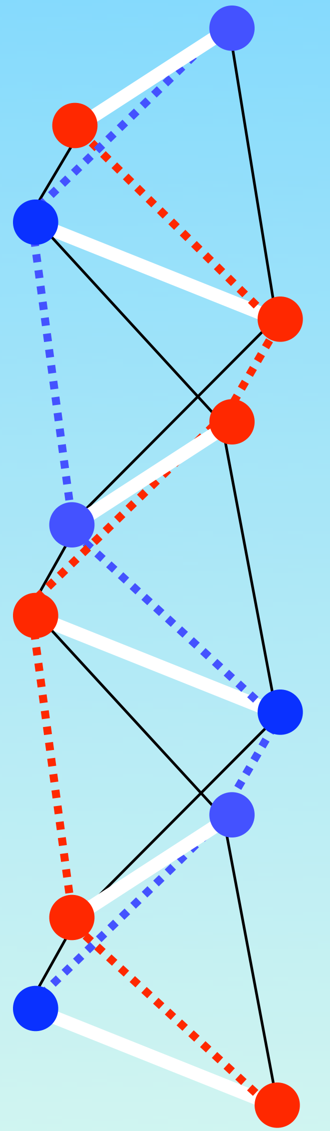
DU Layout

Two contiguous arms of a DU (~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).





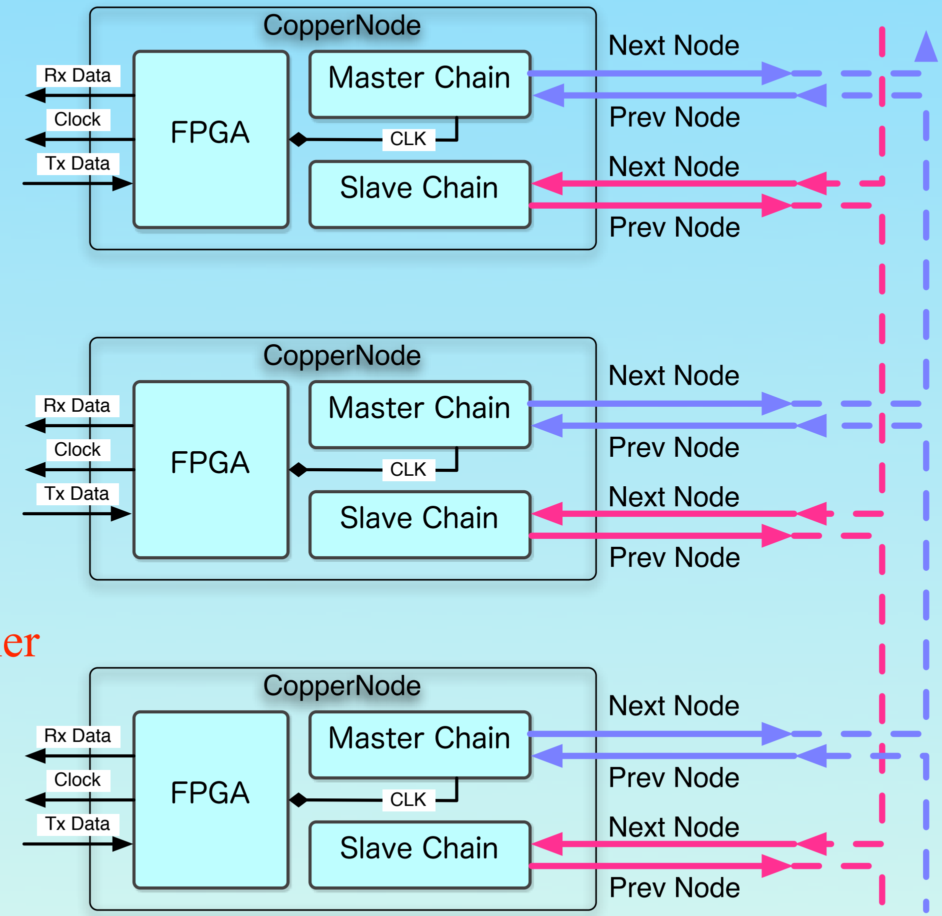
Copper Link requirements

- Constraints:
  - applicable to both Twisted Pairs or Coax cables
  - length of a single hop (maximum 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 (~2W)

Link Implementation: Full Daisy Chain Scheme

The link is bidirectional with asymmetric data rates:

- ◉ Up-going link @163.84 Mb/s for timing and slow control
- ◉ Down-going link @1.18 Gb/s for physics data and control



Pros

- Higher up-going speed
- Nodes are identical

Cons

- Higher Power
- Failure stops higher floors

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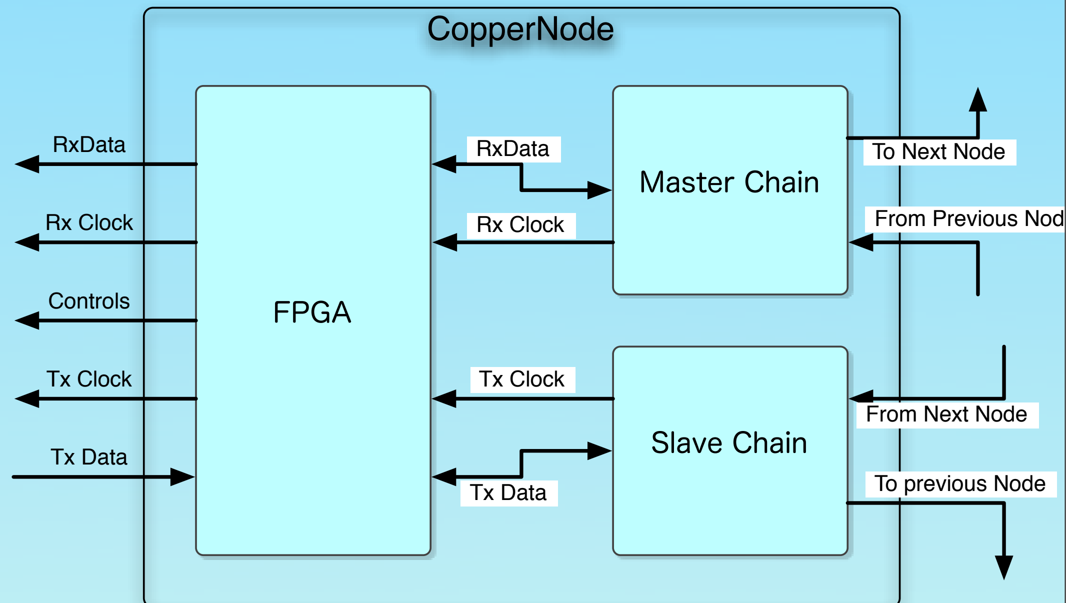
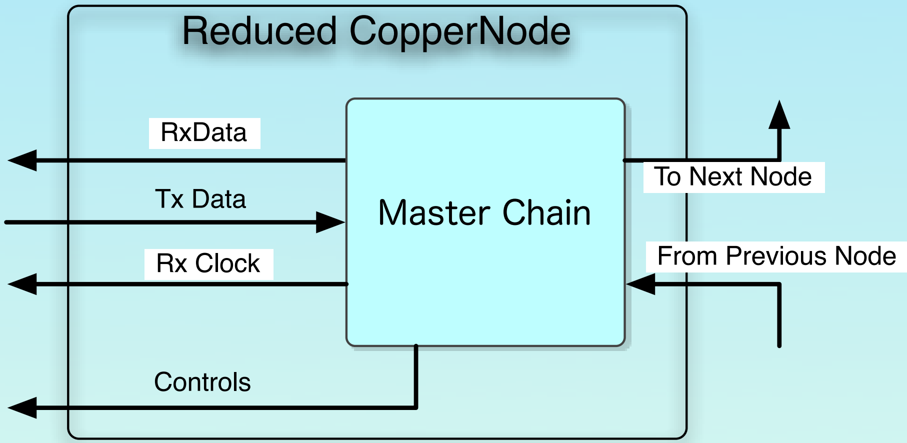
Complete Copper Node Block Diagram

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



Copper Node prototype board

- Only the slow "Master" chain is implemented
- Items under test:
  - clock recovering and cleaning with PLL (max p-p jitter: 105ps);
  - slow channel data Rx and Tx;
  - stand-alone or FPGA driven
  - no definite line interface in order to test different cables



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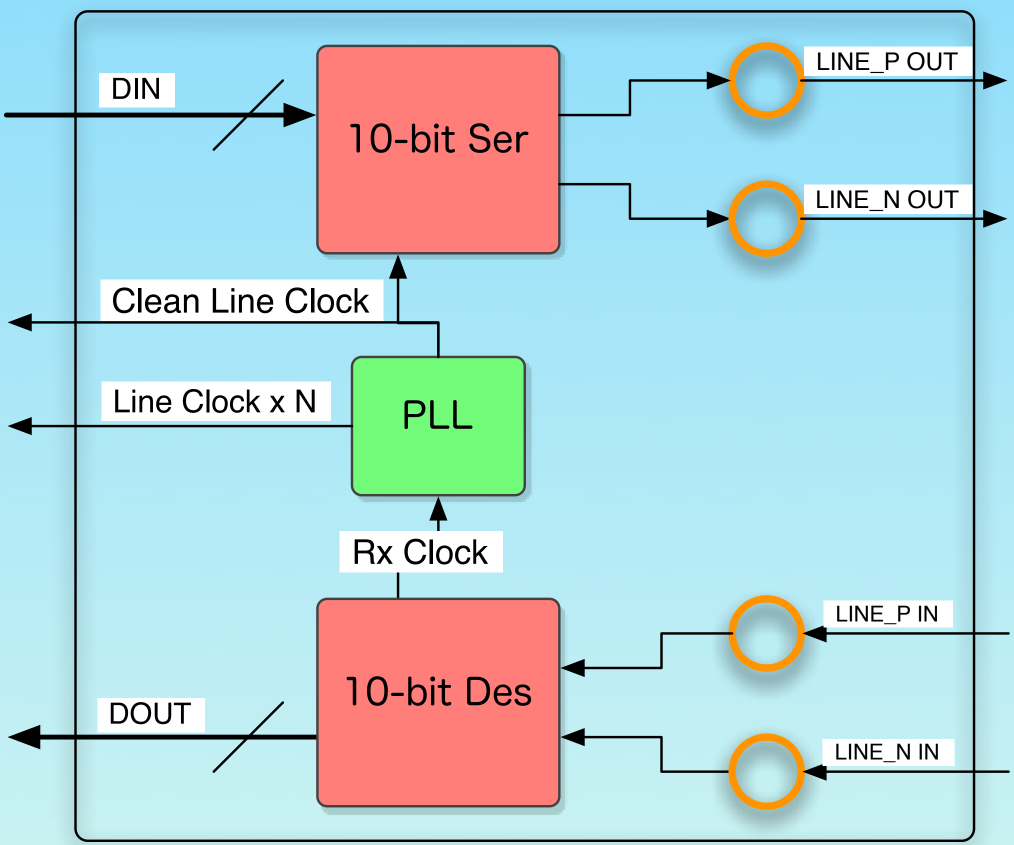
Master Chain Implementation

- Rx clock&data recovery;
- Tx @ same Rx rate;
- line clock cleaning;
- line clock multiplication for high speed chain;
- SMA connectors for line interface.



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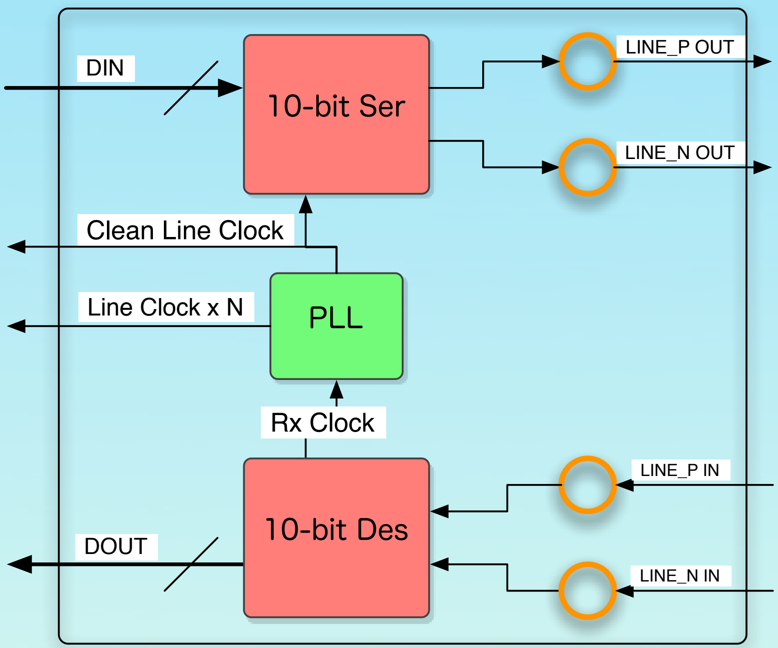
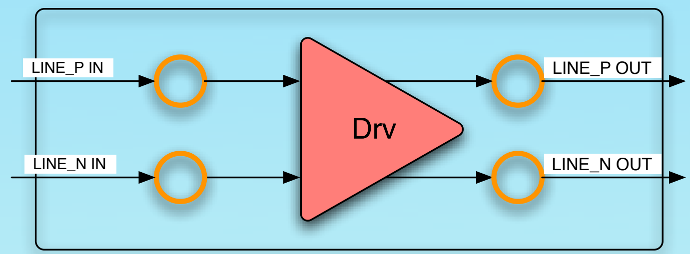
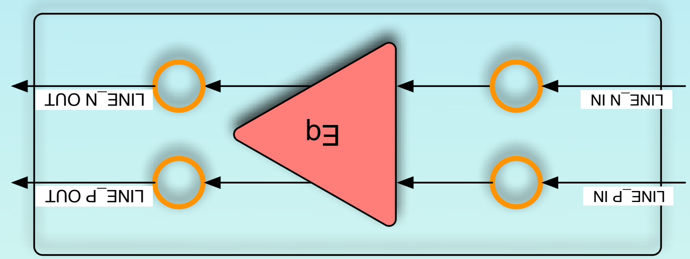
Building the system

- External Driver and Equalizer allow different cables
- Impedance matching boards can be inserted

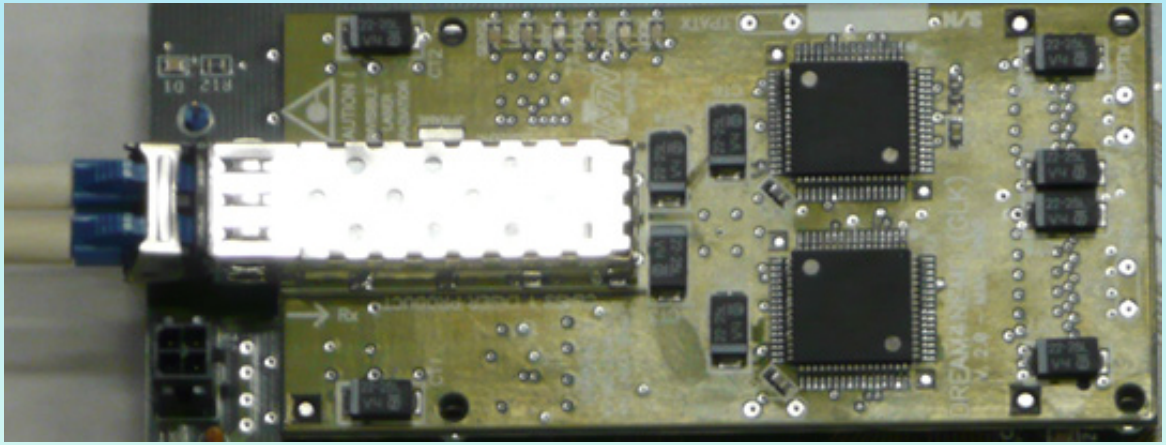






Mezzanine board form factor

- The chosen form-factor is the Nemo mezzanine interface:
  - well defined form factor
  - performances guaranteed up to involved data rates
- Possible testing boards:
  - directly pluggable into Nemo FCM (Spartan3 device)
  - in-directly pluggable into Xilinx ML50x series (V5)



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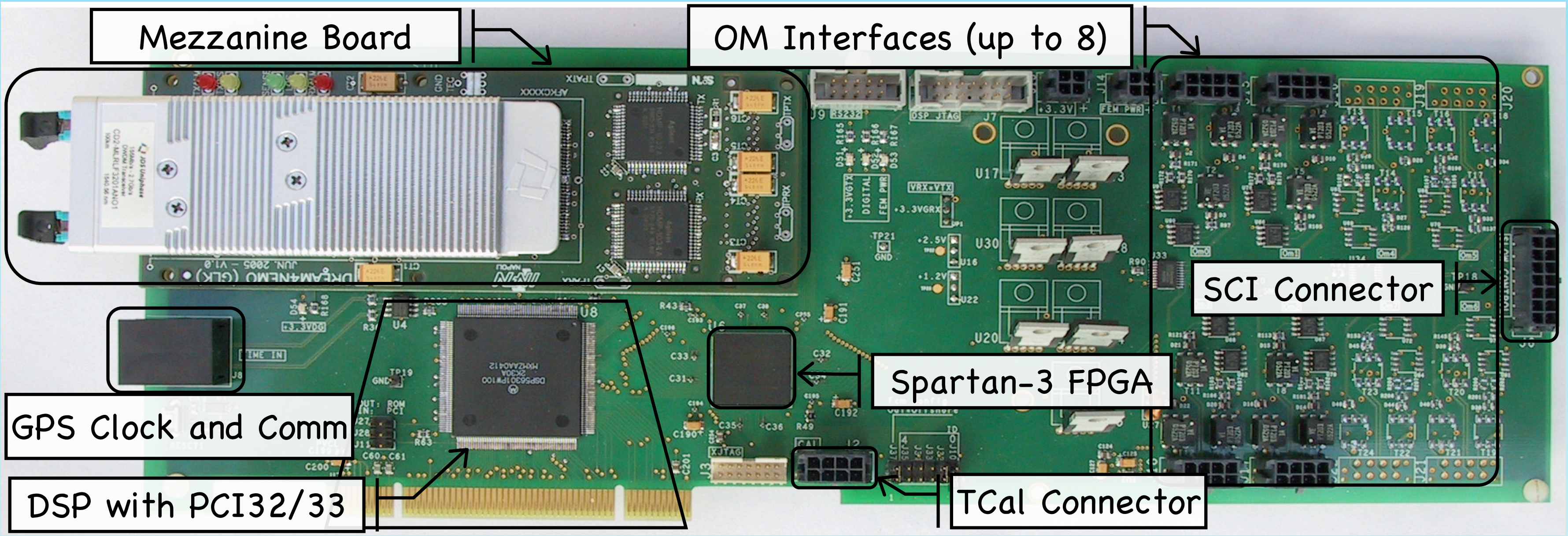
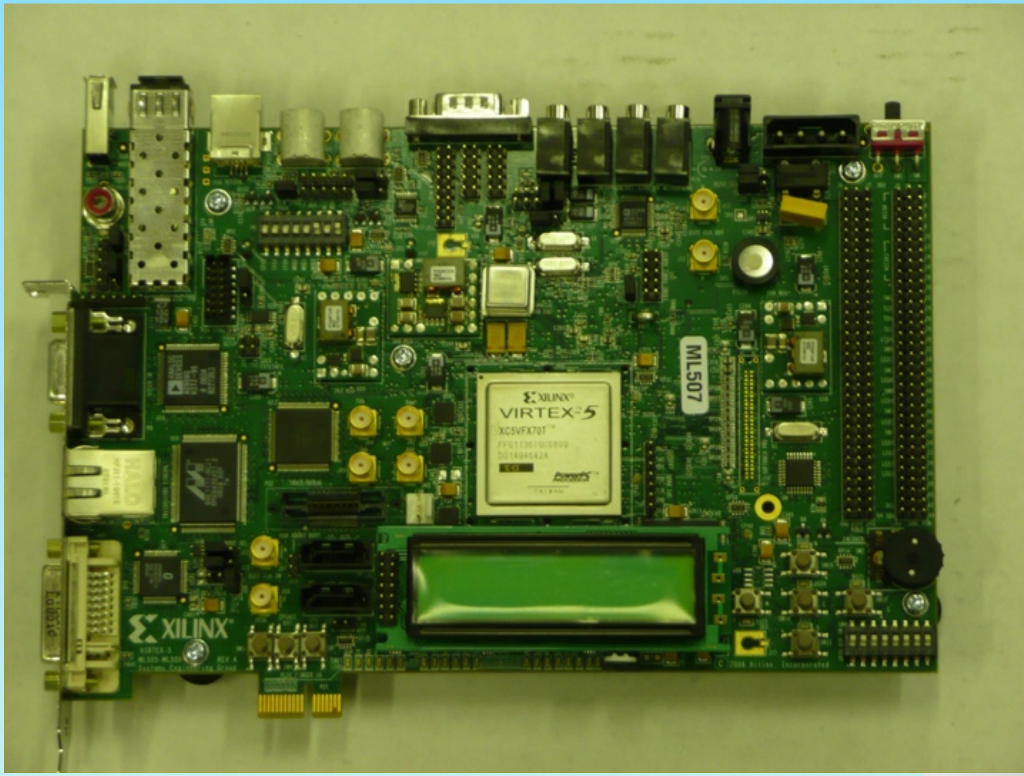
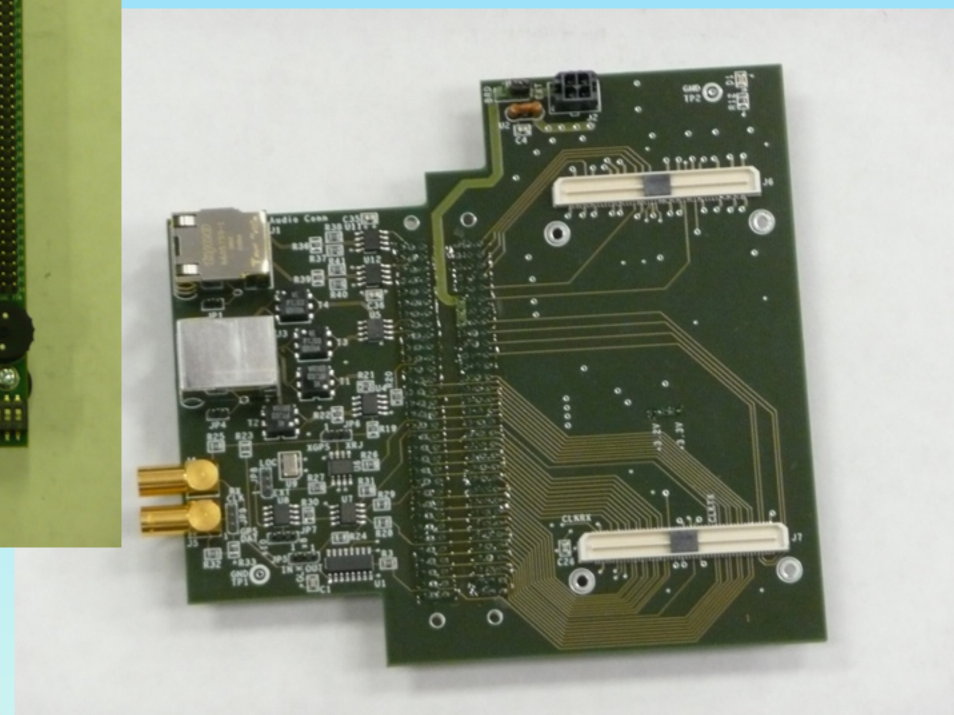
The FCM



Xilinx ML50x adapter: the EtherFcm





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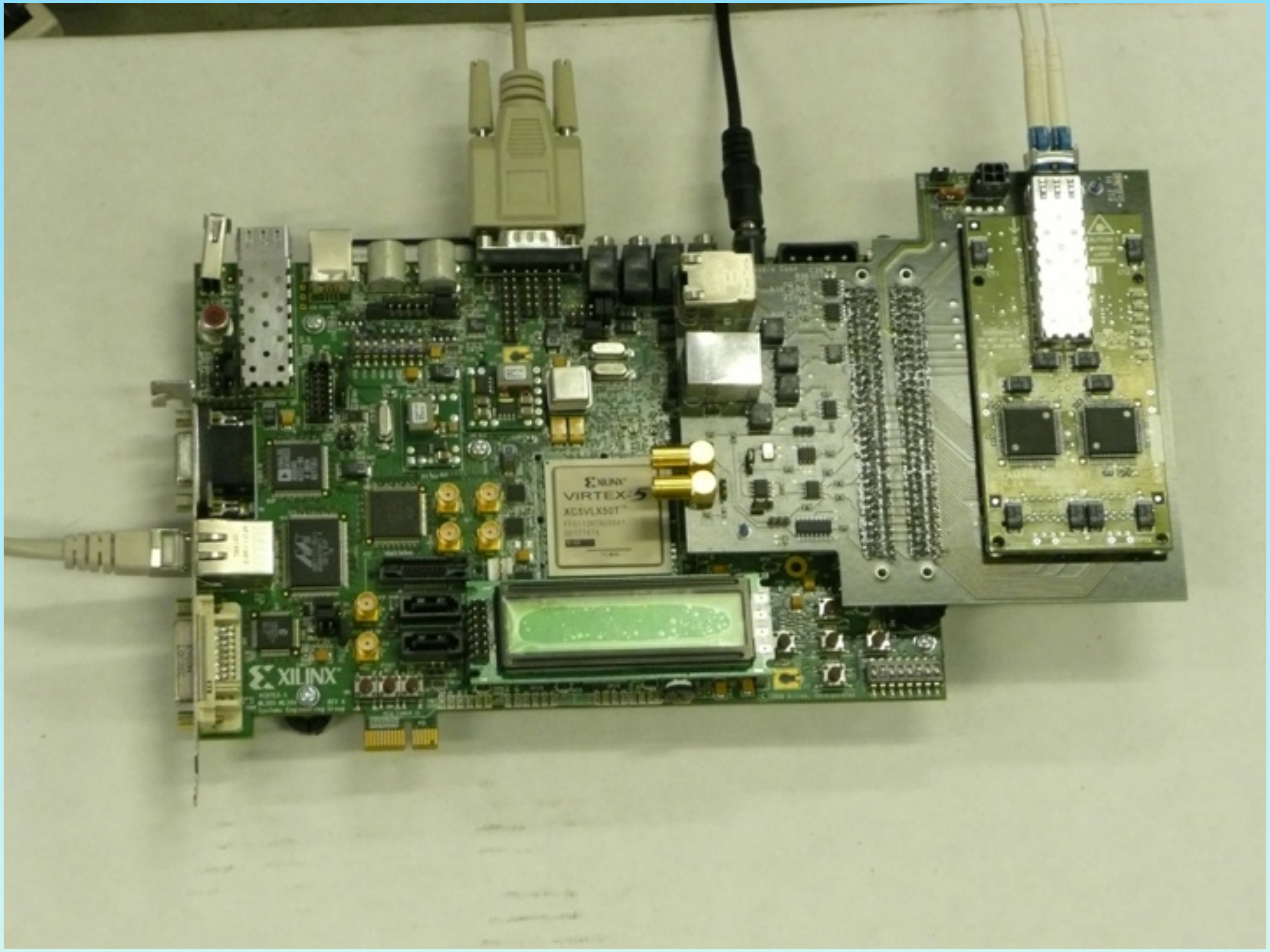
The ML50x stack...



Conclusions regarding copper node prototype

- simple test and debug;
- first samples are arriving next week;
- test of clock and data integrity on slow chain;
- board testing: stand-alone or FPGA driven;
- the daisy-chain protocol can be designed & implemented;
- physical layer flexibility: different cables can be used;

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Trading more backbones for reliability

- Multiple Backbones means redundancy but also an increase in power, cost, complexity;
- Reducing the number of PMs per backbone reduces the overall rate increasing hop length: single node failure could be sectioned out!
- DU JB must mux-demux multiple backbones or use multiple colors;
- DU JB contains 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 over a single twisted pair.

Concluding Remarks

- As many electro-optical transceivers as backbones per DU (with one color per direction per transceiver) are needed.
- One fiber per DU is required; groups of DU can be mux-demux by using DWDM.
- Simple electrical backbone based on 50m long tracts.
- Impact of cables and connectors evaluated separately.
- A procedure for node-to-node timing calibration is under development.
- Dynamical bandwidth allocation allows complete chain flexibility and reconfigurability.
- All the backbone communication burden (bandwidth negotiation, etc.) is user transparent.