ROMANIAN EDUCATION NETWORK

RoEduNet

High Performance Networks

Technologies and Services for Romanian GRID

Octavian Rusu

Agenda

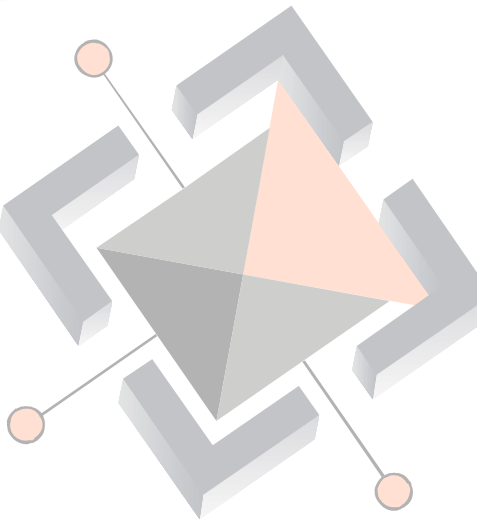
- Trends in networking
  - Customer empowered networks
  - High capacities
  - Optical technology
- Optical technologies
  - CWDM
  - DWDM
- RoEduNet2 project
  - Physical topology
  - Logical topology
  - Costs

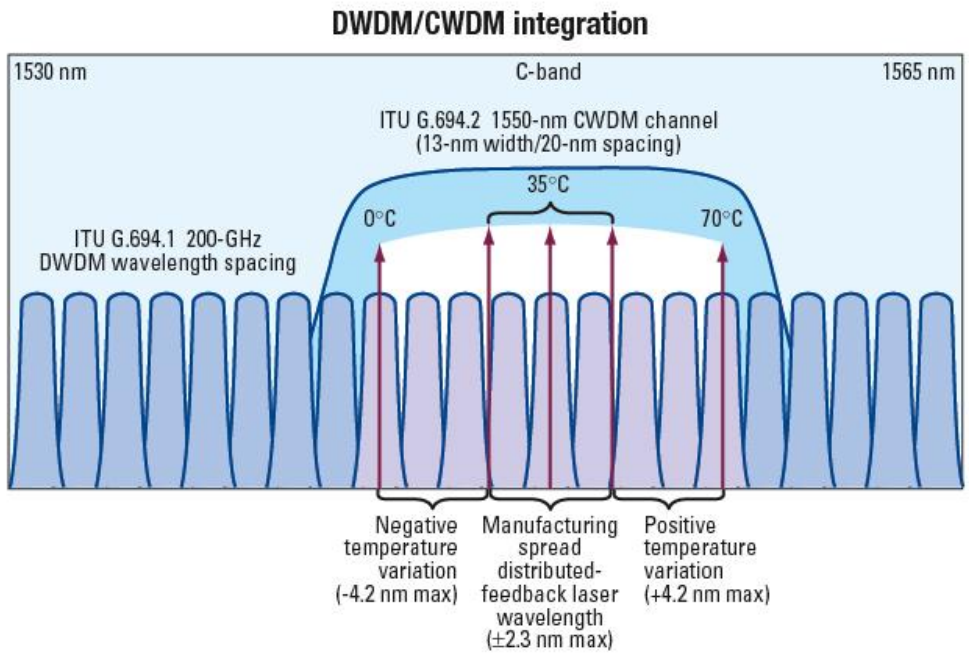
Customer Empowered Networks

- Deployment of technologies enabling customer owned and managed networks
- Result
  - Point to point connection with effective guaranteed bandwidth
- Mechanisms
  - WDM technology using Optical switching
  - VPN using IP services (need for QoS)
- High capacities available on fiber networks
  - Capacities:
    - 10 Gbps Ethernet standardized
    - 40 Gbps Ethernet available
    - 100 Gbps reached in laboratories
  - Span
    - 100 to 120 km NIL as standard
    - Few hundreds km available on some testbeds

Optical Technologies

- CWDM – Coarse WDM
  - To be used in metropolitan networks
- DWDM – Dense WDM
  - Used in long hall networks

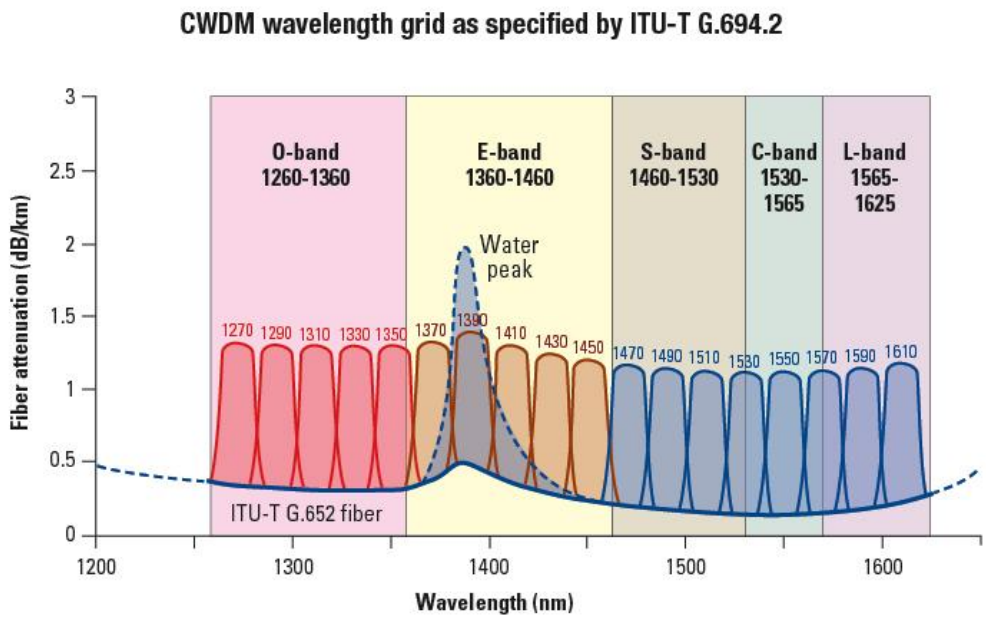




CWDM

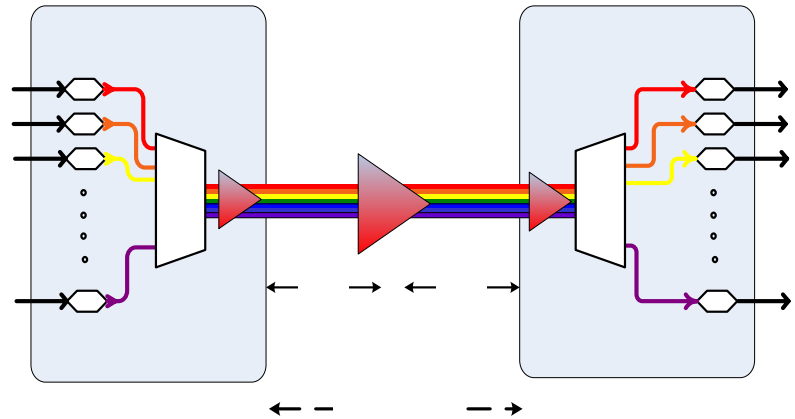
- Characteristics
  - Span: about 100 km, otherwise requires one amplifier per wavelength
  - Speed: 10 Gbps (theoretically) but 1Gbps widely deployed
  - Number of channels
    - 17-18 maximum (according to ITU-T G.694.2)
    - 8 widely used

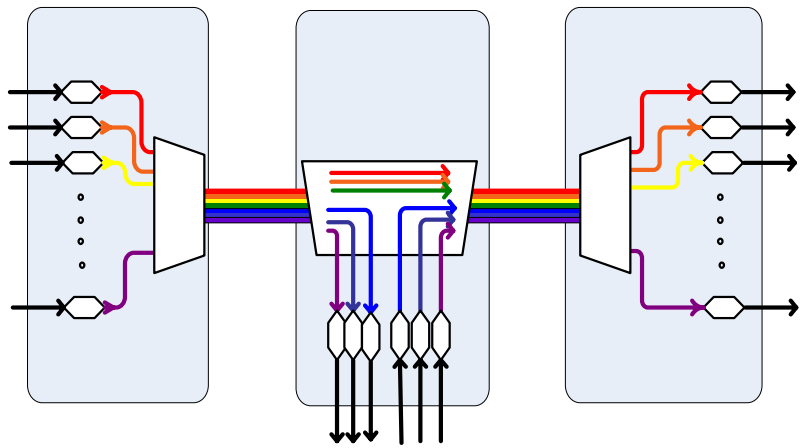
- Usage:
  - Metropolitan Area Network
  - *Usually does not support SONET/SDH*



DWDM

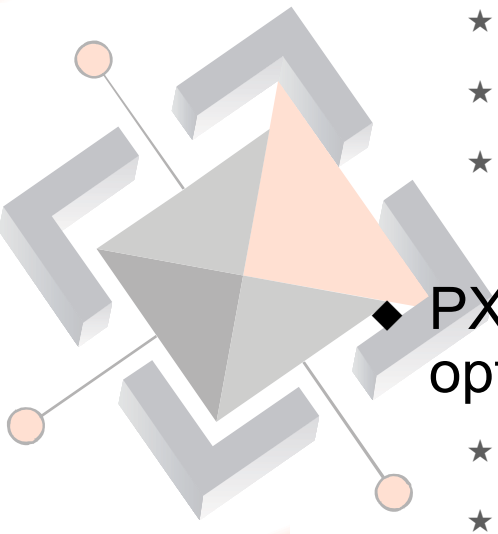
- Characteristics
  - Span: NIL about 120 km
  - About 500 to 1000 km with EDFA (one per C band) without OEO regeneration;
  - Speed: 1, 10 and 40 Gbps, also STM 1 to STM 256 per lambda
  - Number of channels
    - Up to 160 - 190
    - Usually 32 or 40 upgradeable to 64 or 80
- Usage:
  - National networks
  - Regional networks





Optical Switching

- Two types of devices:
  - OXC – Optical Cross Connect (OEO switches) – electronic cross connects with optical interfaces
    - Perform 3R: amplification, reshaping and retiming
    - Mature technology
    - Affordable in some conditions
  - PXC – Photonic Cross Connects (OOO switches) - all optical
    - Immature technology
    - Research needed

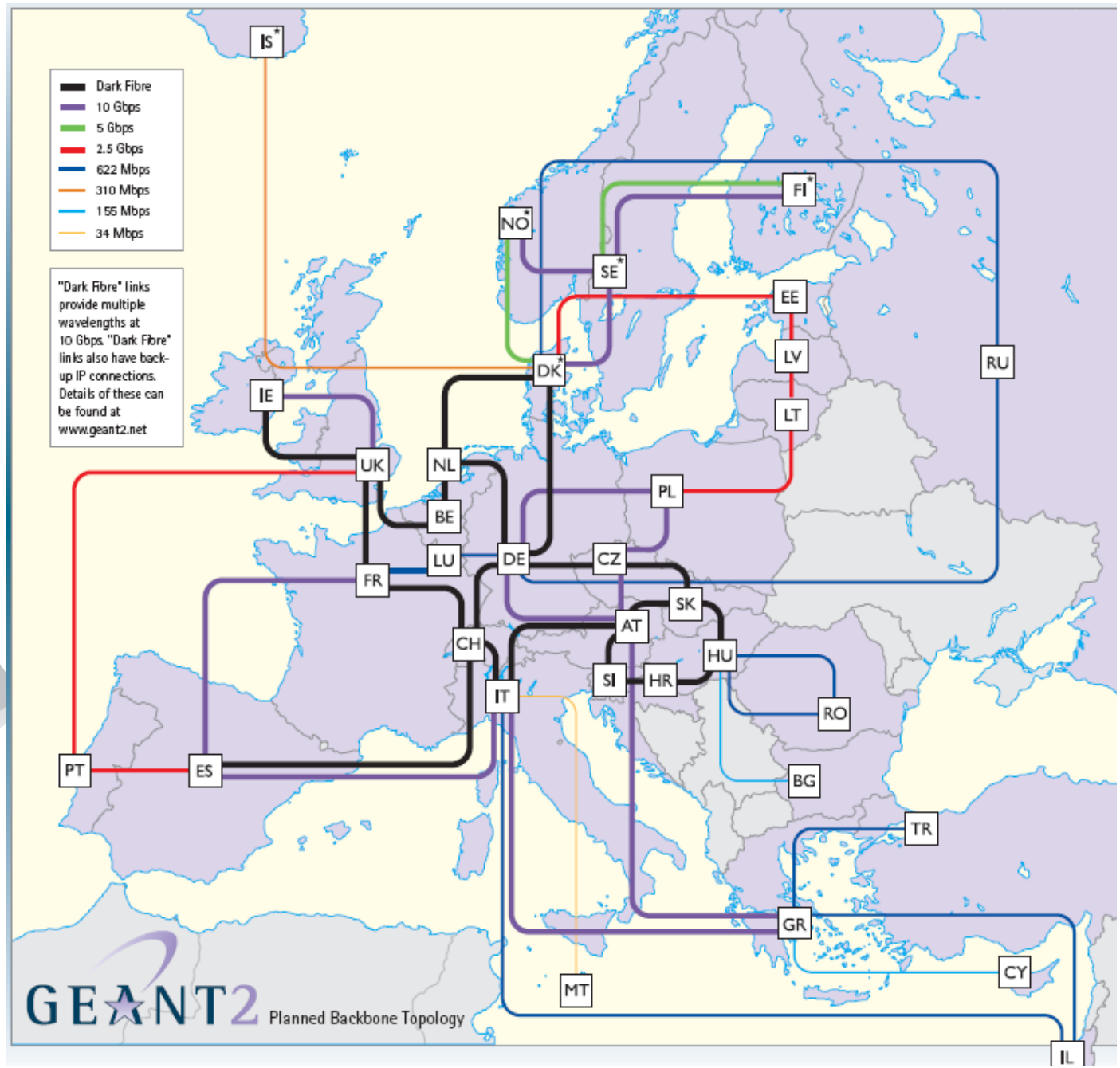


About RoEduNet

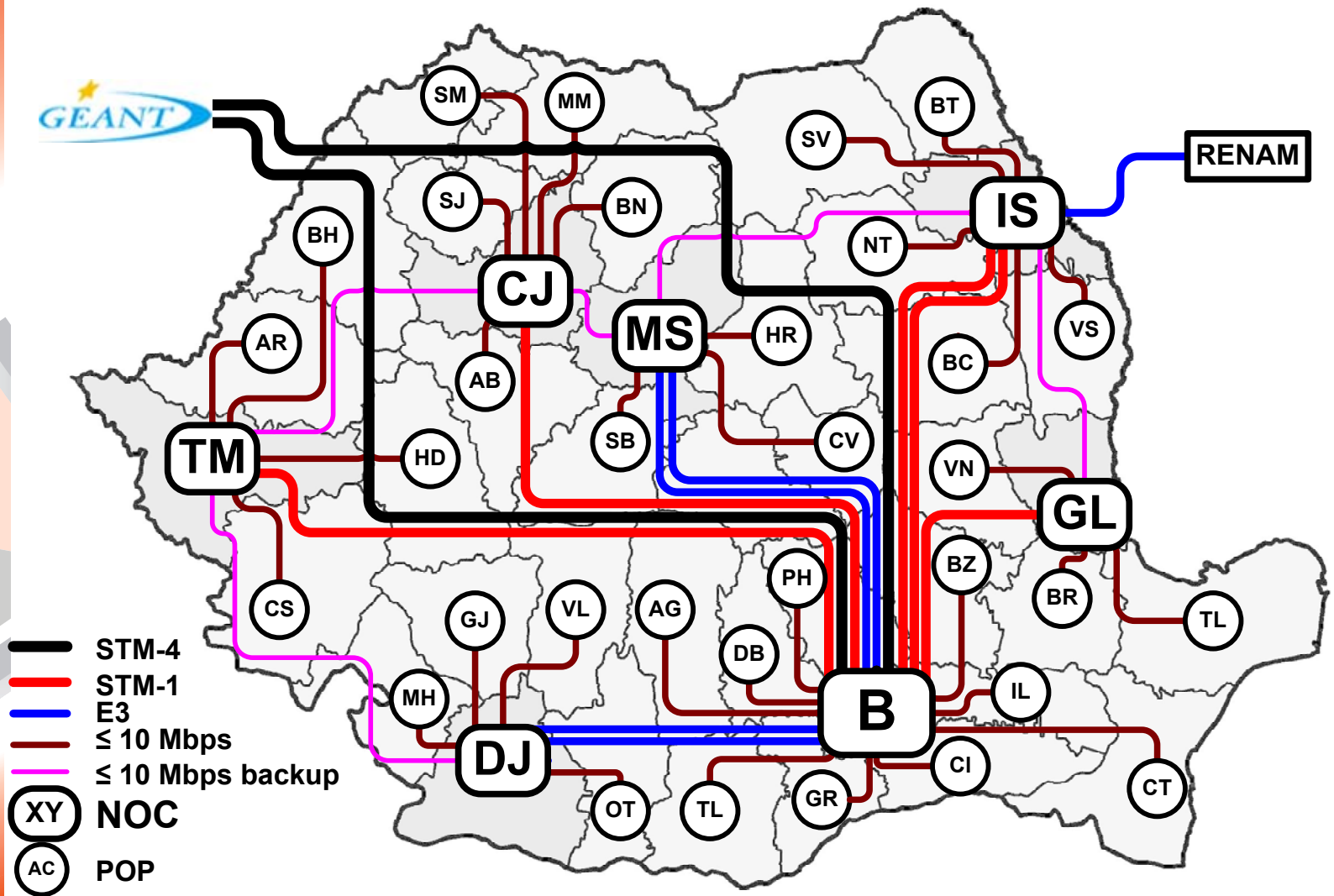
- August 1998
  - RoEduNet officially founded through a Romanian Government decision (HG 515/August 21)
- October 2000
  - First connection to GEANT (34 Mbps)
- November 2002
  - STM1 connection to GEANT
- May 2003
  - STM4 connection to GEANT
- June 2005
  - ***Agreement to build a common DWDM network with SC Telecomunicatii CFR***
- September 2005
  - HG 1056 – RoEduNet is stated as the single Romanian NREN
- November 2005
  - 2 x STM4 connections to GEANT
    - Subscription only for 622 Mbps to the GEANT network

RoEduNet

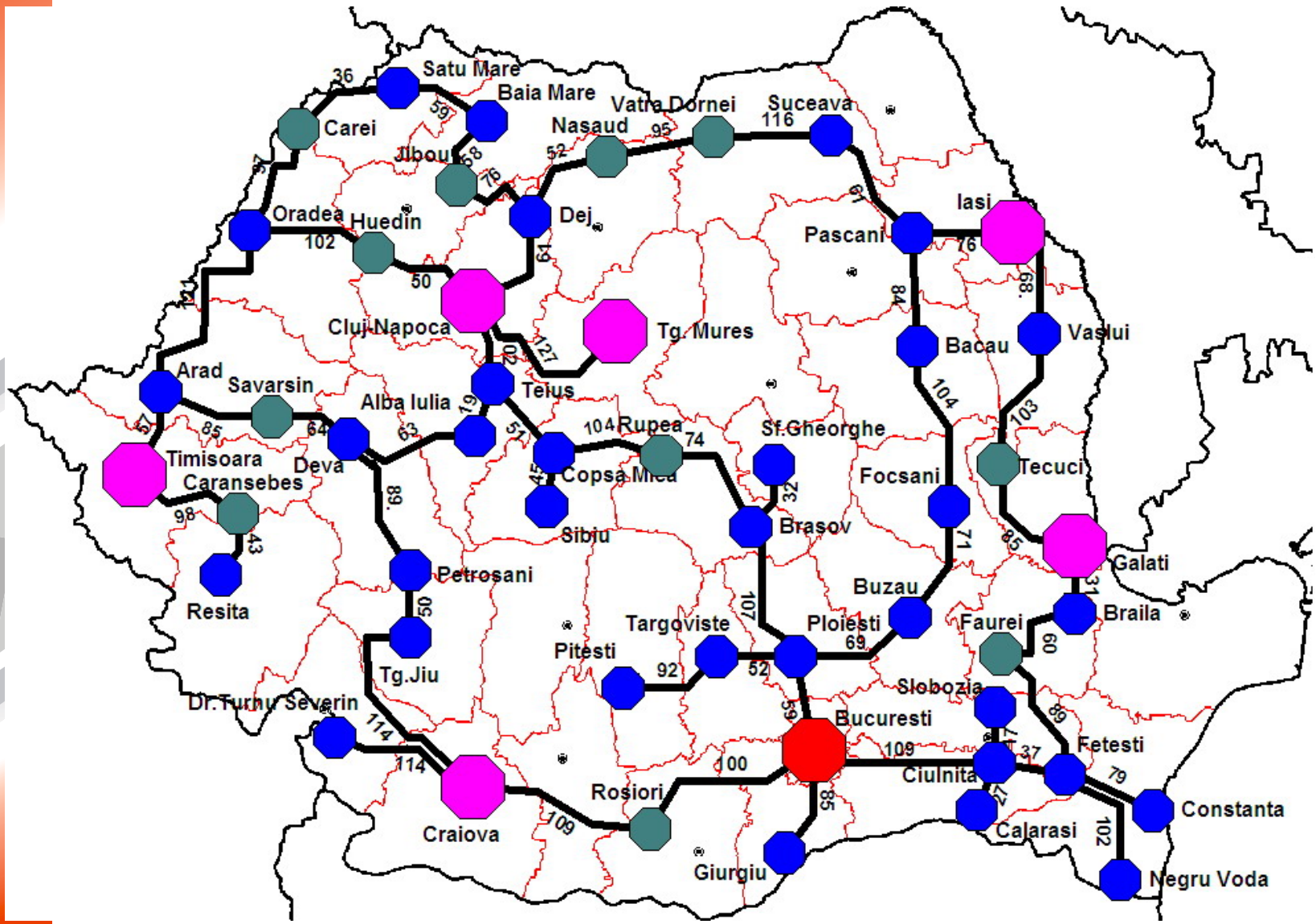
RoEduNet in GEANT



RoEduNet Actual Topology

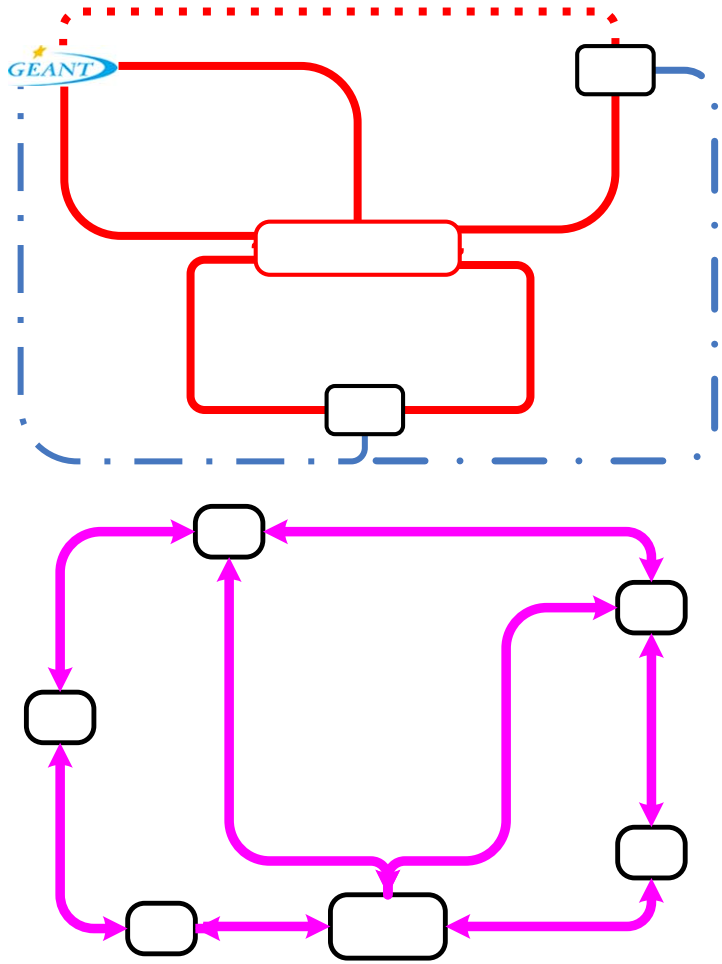


RoEduNet 2 DF Topology

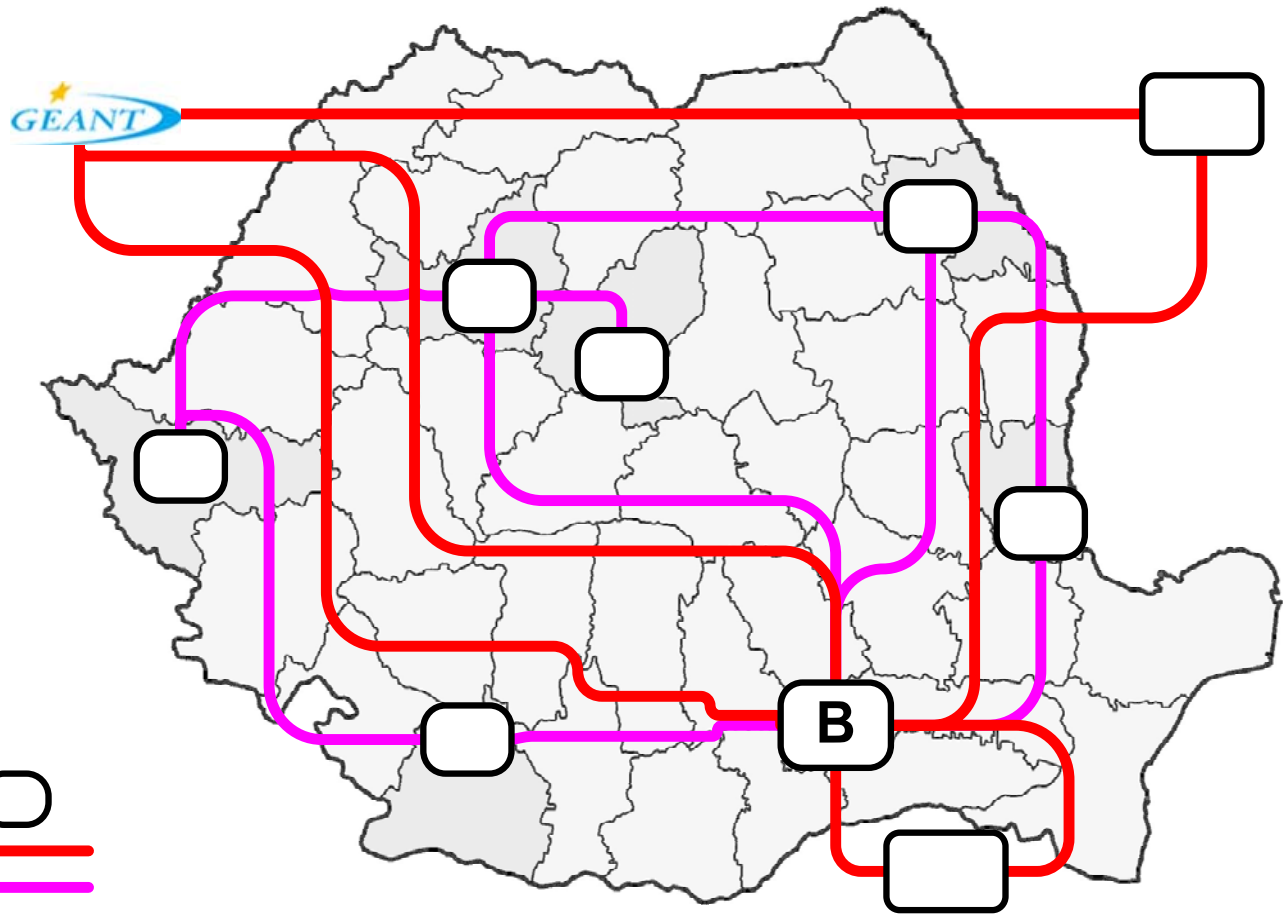


RoEduNet 2 Layer 0 Links

- GEANT connectivity
  - Bucharest – Budapest: 10 Gbps using two separate paths to Romanian border, *additional lambdas can be added (about 150 KEuros per link for equipments)*
  - Bucharest – Sofia: 10 Gbps – discussions with ISTF
- Support for European projects:
  - Black Sea Network initiative (support from the EC to reduce digital divide)
  - Two paths to be provided through Romania:
    - Moldova to Georgia
    - Turkey through Bulgaria
  - Iaşi to Chişinău DF link to be funded by the EC
- NOC connectivity at 10 Gbps in a ring topology at IP level
  - DWDM unprotected to cut down costs
- Topology determined by the DF topology

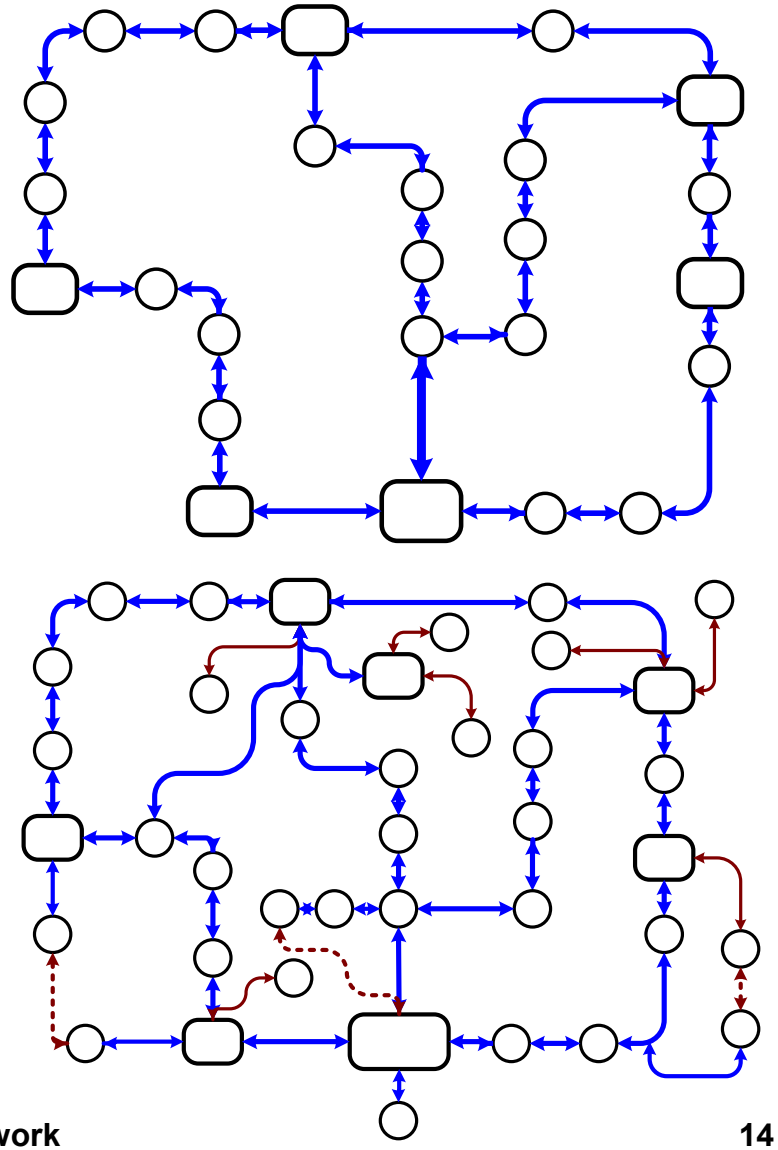


RoEduNet 2 Layer 0 Topology

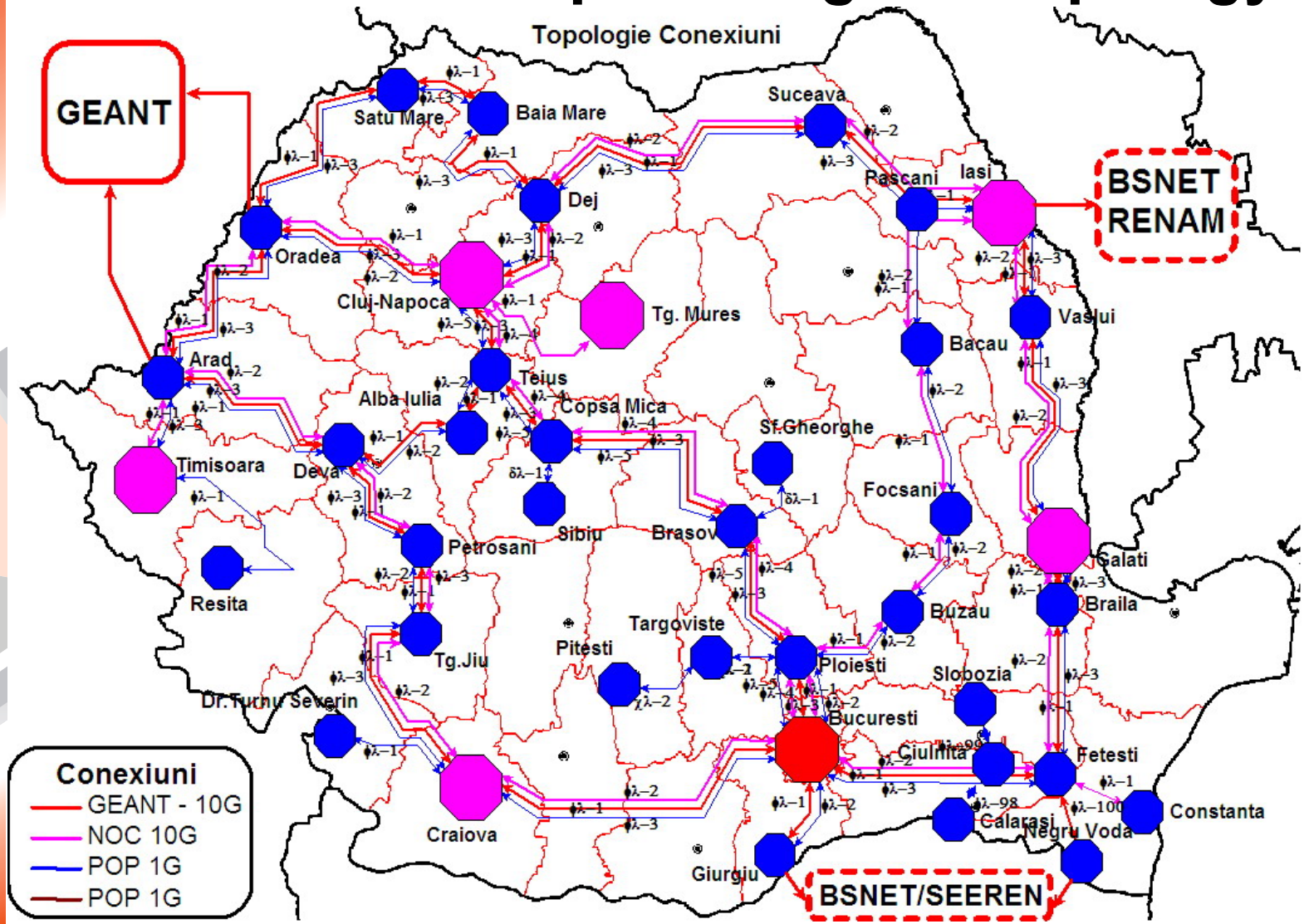


RoEduNet2 Layer 1 Topology

- POPs will be connected on the same paths used for inter-NOC links but using 1Gbps links
- Using this topology each POP is connected with 2 NOCs providing traffic rerouting in case of failure (*not for metropolitan fiber links – IP switches will be used to avoid connectivity breaks in case of metropolitan segment failure*)
- Each POP can be connected at 4x1Gbps using CDWM for the local loop (for the POPs where Universities are located)
  - These lambdas can be used for a separate testbed for Romanian GRID
- Based on DF Topology some POPs will not be connected using DF from Telecomunicatii CFR (brown links) but we expect to able to make capacities exchange to cover all POP as in the picture

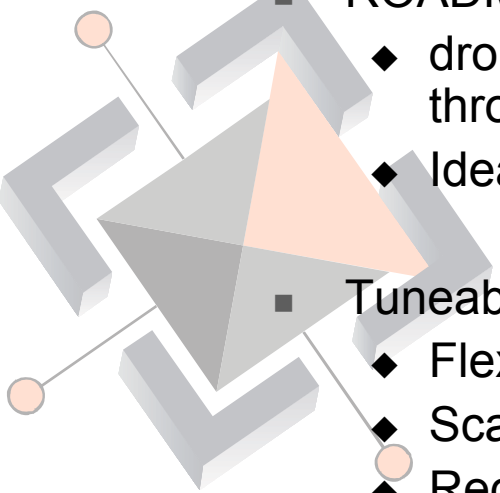


RoEduNet2 Complete Logical Topology



Technologies for RoEduNet2

- DWDM fully meshed (complex topology)
  - At least 32 (40) lambdas upgradeable to 64 (80)
  - CDWM to be used for metropolitan links (Railway station to RoEduNet POP for POPs hosting Universities)
- ROADM – Reconfigurable Optical Add-Drop Multiplexer
  - dropping or adding wavelengths does not interrupt the 'pass-through' channels
  - Ideal for lambdas on demand
- Tuneable lasers
  - Flexibility
  - Scalability
  - Reduced costs



RoEduNet2 Estimated Costs

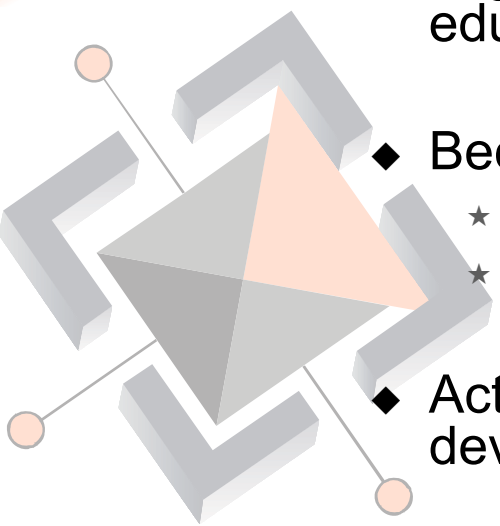
- International links
  - Estimated cost for SEELight – Romanian segment on the path Athens-Sofia-Bucharest-Budapest
  - 10 years DF + co-location + equipments = 6.902 k€
- National network
  - Estimated costs according to SEEFIRE results (taxes not included) :
    - DF for 10 years: 4150 km with maintenance, 3 €/m = 12.393 k€
    - co-location including electrical power: 10 years, 1000 €/month/rack = 4.957 k€ (should be cheaper …)
    - equipments costs:
      - 1 x 10 Gbps DWDM+IP: 3864k€/1000km = 1635.6 k€ (204.6€/Mbps/year)
      - 4 x 10 Gbps DWDM+IP: 7524k€/1000km = 31224.6 k€ (87.7€/Mbps/year)

RoEduNet2 Calculated Costs

- DF and co-location – no costs – based on Collaboration contract with SN Telecomunicatii CFR (saving about 16 M€);
- Optical switching equipments = 12300 k€ (about 52 MRON including VAT);
- Local loop = 2.400 k€ (about 10 MRON including VAT);
- IP equipments (only switches and 10 Gbps interfaces for existing routers) = 1.800 k€ (about 7.5 MRON including VAT) – action already started, should end in December.

Conclusions

- RoEduNet is the basic layer of the Romanian GRID
- As a result RoEduNet should:
  - migrate to RoEduNet2 – optical national research and education network;
  - Become GN2 POP:
    - At least 10Gbps to GEANT **AND**
    - At least connected with 2 NRENs
  - Actively participate in Eastern European networking development providing connectivity for the Black Sea area
  - Provide independent services for GRID (dedicated lambdas)



Thank You!

- Questions