

Migrating to a Next Gen WDM Network

Orange Labs

research & development

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Presentation Outline

- The convergence toward all over IP and the fast growth of the traffic make clearly the **WDM layer** as the **core transport federating layer**
- This **case study**, performed on the **France Telecom WDM network** shows that
 - **Semi-transparent network architectures** allows for **significant CAPEX saving**
 - **WB and WSS** introduction dramatically **simplifies network architectures** and **planning activity**
 - They also bring additional **CAPEX savings**
 - Migrating to a **fully agile "Next Gen" WDM network** might be **challenging** with currently proposed architectures

Agenda

- 1 Context
- 2 Methodology and assumptions
- 3 Studied scenario
- 4 Architectures benchmarking
- 5 Getting to a fully transparent Agile Core WDM network
- 6 Conclusion

Context

- Global review
 - Convergence toward all over IP
 - Fast growth of the traffic
 - FTTH acting as an accelerator
 - ➔ WDM layer is clearly identified as the core transport federating layer
- WDM equipment evolution
 - Evolution on LH systems almost frozen during the last years and mainly focused on increasing transmission rates
 - WSS available
 - GMPLS on the way to be integrated in LH transport network
 - Some solutions proposed to handle physical impairments
- France Telecom Core Network evolution
 - ELH system already deployed → 80 x 10 Gbps
 - Still old generation WDM system deployed to be updated
 - The transition shall be carefully managed: need to analyse the best option for the network evolution,

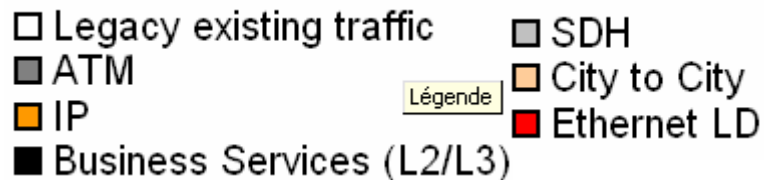
Assumptions

■ Source optical infrastructure

- France Telecom European Backbone Network
 - 21 000 km of WDM systems crossing 92 Add/Drop nodes
 - 190 line sites
- Real span attenuation, PMD, and chromatic dispersion used for the simulation

■ Traffic matrix

- Existing traffic currently routed on the existing WDM network
- Forecasted traffic until 2010
 - GE STM-16/STM64 and 10 GbE demands



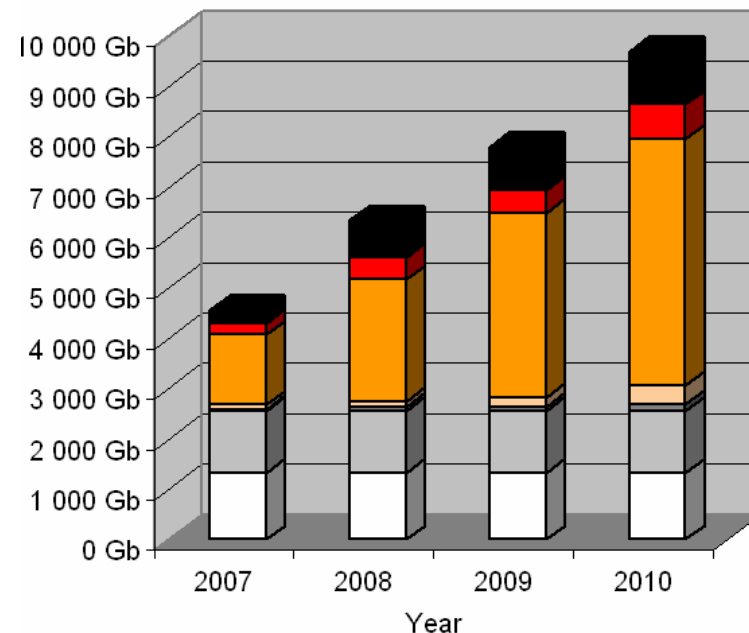
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Studied network topology

Network size	92 Nodes	99 links	
Max. shortest path	15 Hops	1982 km	
Parameter	Average	Minimu	Maximum
Link length	226 km, 3 spans	2km, 1 span	797 km, 11 spans
Span length	72.9 km	2 km	129 km
Node Degree	2.15	1	4

Traffic distribution, Existing + Forecast



Network Topology based on a Hybrid Transparent partitioned architecture

- Hybrid transparent : variation of the transparent network in which electronic regeneration is authorized to relieve the cost of the network and simplify its engineering.

- End to end connectivity is mainly achieved through optical switching, either manual or automatic

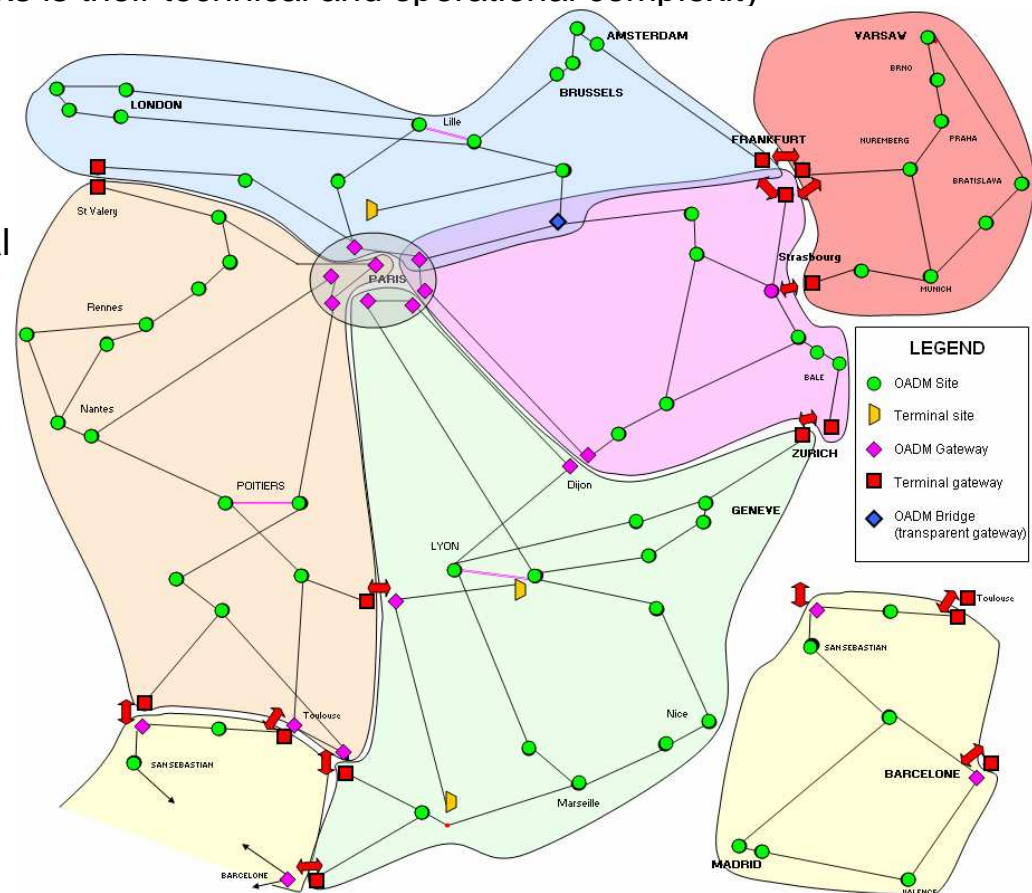
- Partitioning :

- A big issue of integrated optical networks is their technical and operational complexity

- Partitioning the network in several sub-networks allows for simplifying network operation and network engineering (limits wavelength contention issues)

- Each sub-network has dedicated optical equipment.

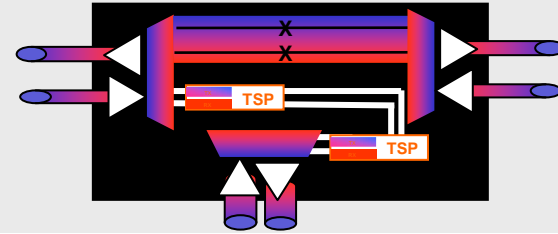
➔ Some cities of the network act as boundaries of the subnetworks. In these cities, regeneration is mandatory to pass from a subnetwork to another



Different Scenarios according to the node transit option

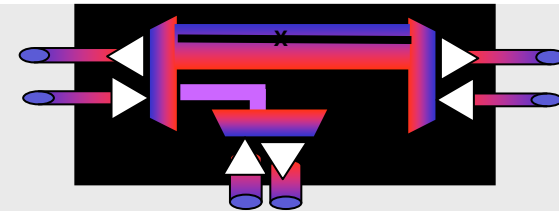
– Scenario 1 : "Legacy with WB"

- ➔ Express transit on main direction implemented through Wavelength blocker
- ➔ Regeneration on secondary directions



– Scenario 2 : "WB with optical bypass"

- ➔ Express transit on main direction (Wavelength blocker) and secondary direction (optical bypass at band level)

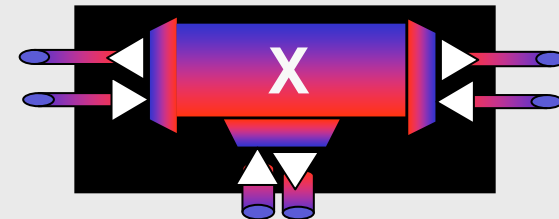


– Scenario 3 : "WSS"

- ➔ WSS (Wavelength Selective Switch) is used to provide wavelength switching from a direction to an other

– Scenario 4 : "WSS Fully Tunable"

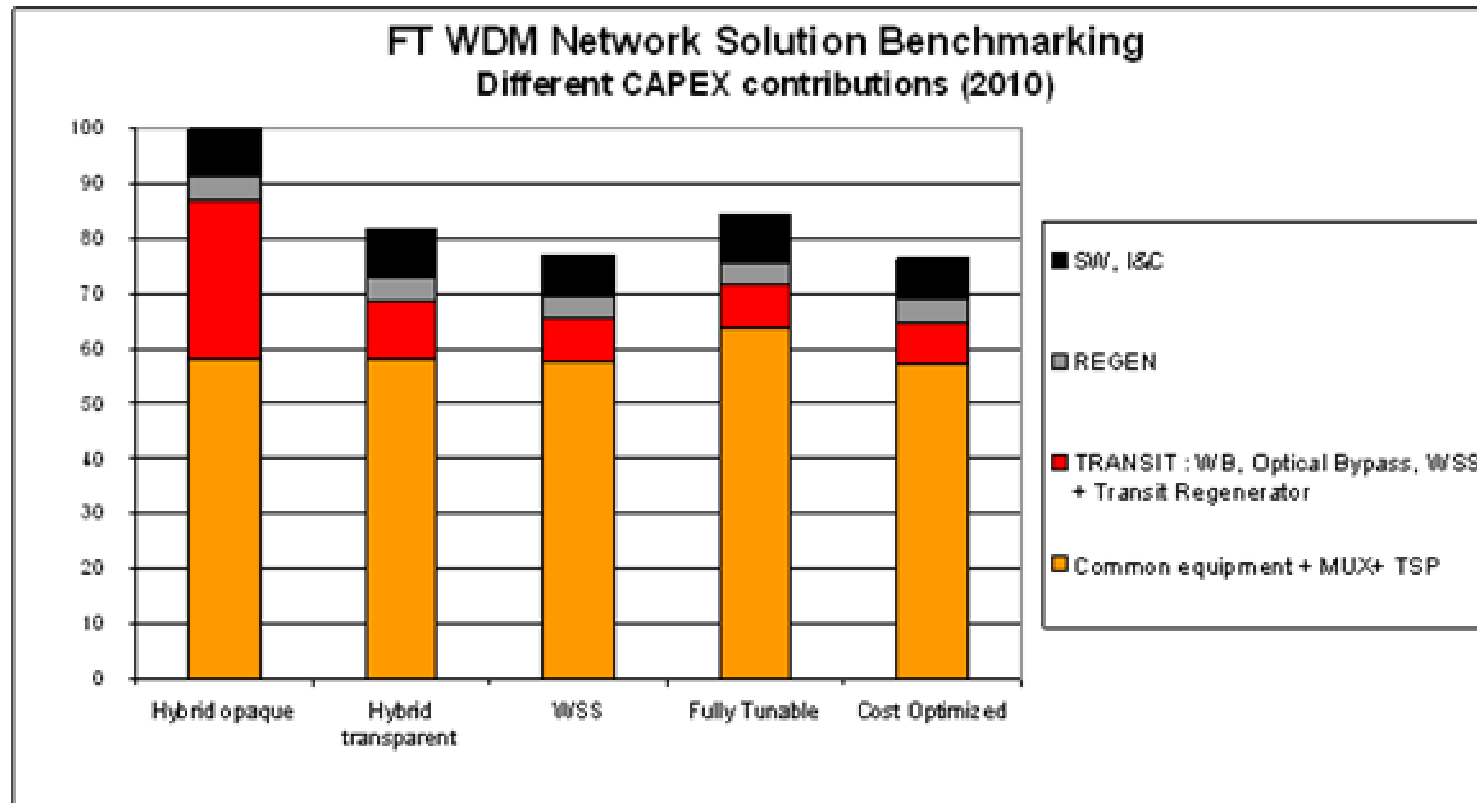
- ➔ Scenario 3 + WSS used for colourless channel add/drop



– Scenario 5 : "Optimized"

- ➔ Best (most cost-effective) option selected on a site by site basis

Scenario Benchmarking : 2010 results



	Hybrid opaque	Hybrid transparent	WSS	Fully Tunable	Optimized
Traffic up to 2007	100	85	80	89	79
Savings /Ref		15%	20%	11%	21%
Traffic up to 2010	100	82	77	84	76
Savings /Ref		18%	23%	16%	24%

– Network load (2010) : Average link load = 30 %, Maximum load 81 %

Architecture benchmarking Analysis

- Implementing optical bypass for transit in secondary directions allows for significant savings (up to 18%)
 - Reduces the number of transit regenerators
 - This solution is almost available today for nodes up to degree 4
 - Complicates Network Engineering, planning and operation
 - Network cost is strongly connected to the bypass granularity and the wavelength allocation strategy
- WSS based ROADM seems to be a really interesting option
 - Costs are comparable to previous solution (allows for gaining 5 points of savings)
 - Adds flexibility in the network
 - Helps handling wavelength allocation on the different paths
- Fully tunable ROADM increase global cost for a limited short term interest
 - Studied solutions is based on single stage WSS configuration
- An optimized scenario, where the configuration is selected on a site by site basis allows for limited savings in comparison with the 3rd scenario (WSS based ROADM)
 - WSS based ROADM could be deployed in every site to simplify network planning & engineering
- The gain observed for scenario 2 and 3 increases with the network load

No Dramatic OPEX savings expected

■ Business rates

- Directly proportional to the CAPEX

■ Network planning & Engineering

- WSS and WB will simplify network planning
 - Should reduce the contention level
 - Simplified link to link transit and band management (Wavelength grid easy to manage)
- However, one must consider that transparency complicates network engineering
 - Traditional WDM Network : 1 shot engineering day one
 - Hybrid Transparent network : engineering required for each new channel to be provisioned

■ Network operation

- WSS and WB will simplify network operation
- Improved reliability
- End to end provisioning done remotely, on site operations needed only at end sites
- Less equipment to deploy (simplified link to link transit and band management)

■ Expected Labour OPEX savings are limited for the Core network:

- The global core network has a limited meshing level
- Traffic is more predictable than in the metro
 - Limited topological change through network life
- Number of link creations over one year is lower
- Centralized engineering, planning & operation → Limited human resources

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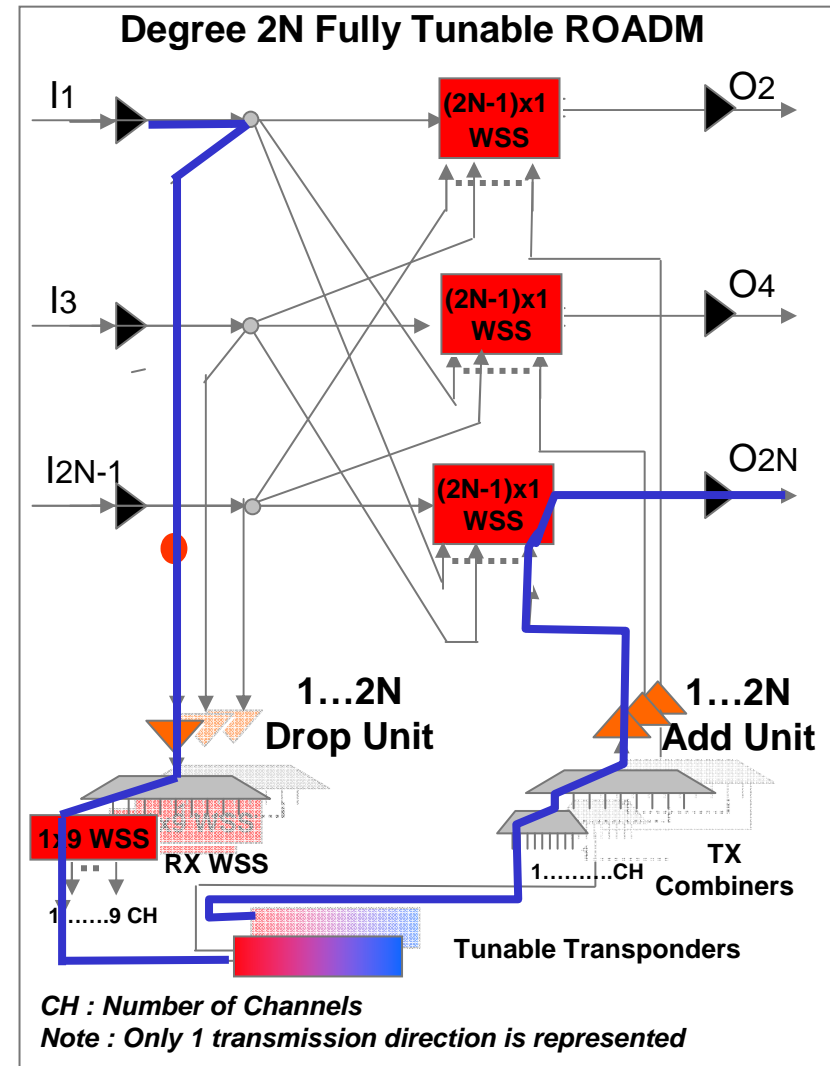
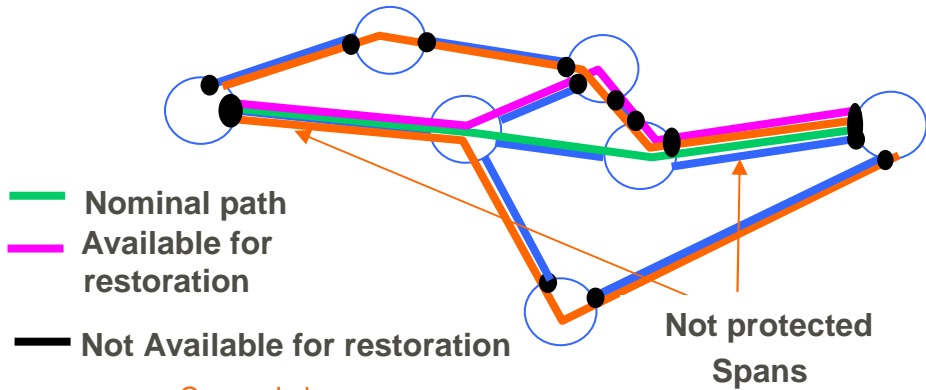
Migrating to an agile WDM network

- Tunability is required in the context of a Control plane deployment
 - Wavelength tuning is needed to
 - Solve conflict while rerouting
 - Handle wavelength contention
 - Configure pre-installed regenerator pools
 - Shall be associated with directionless feature
- But full tunability will probably not bring saving expectations
 - No dramatic OPEX savings expected
 - Human field operation still required on each end to connect client equipment
 - Limited CAPEX saving getting from protection to restoration
 - Wavelength granularity
 - Increases dramatically the CAPEX
 - OPEX savings implies the use of pools of transponders in some sites
 - WSS costs will never reach the Mux/demux cost level
 - OXC have still high price per port
- Partial tunability may be the best option
 - Considering agility only for a subset of the services
 - Using Bridge and Roll features to migrate smoothly dynamic services to fixed services
 - Using PXC or OXC with reserve resources to limit the number of WSS

Basic Tunable OADM configuration

- Colorless Add/drop provided through
 - WSS at the RX side
 - Combiner at the TX side
- Overspend for Full tunability
 - 20 to 25 % for the node
 - + 1.7 k€/Channel
- Limited advantages
 - Simplified path provisioning
 - On field operation still required to connect client equipment
 - Does not allow for dynamic end to end restoration
 - 1 transponder is physically connected to one branch of a node

➔ As a result, first and last span can not be protected against failure through this configuration

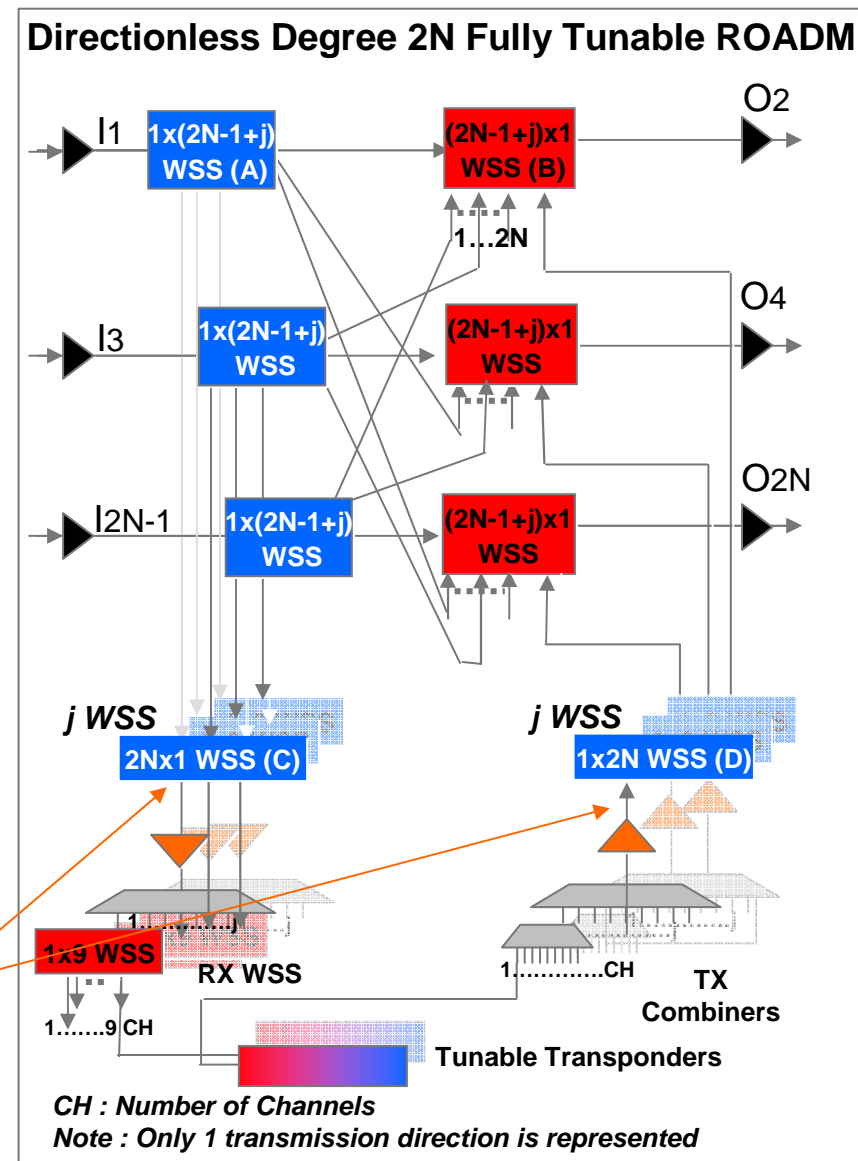


$$N_{WSS} = (N + \sum_{i=1}^N [\text{Int}(\text{Chi}/9) + 1])$$

Chi = N.ber of A/D channel on direction i

Directionless Fully tunable ROADMs

- Directionless feature allows for end to end protection
 - Any transponder potentially connects to any node branch
 - Increase dramatically the number of WSS
 - AxN WSS, with A = 2 to 4 (if WSS C and D are used with j=N)
 - Estimated overspend for directionless Full tunability
 - For a site of degree 3, of average load (A=4)
 - ➔ 48% of the global site cost (excluding TSP)
 - ➔ + 15% of the channel cost
- Configuration becomes really complex
 - High quantity of equipment crossed
 - High footprint and power consumption
 - Blocking
 - During a path reconfiguration (after a Network failure), a TSP might be tune to another wavelength to solve contention issues
 - ➔ It can not be tune to the same wavelength as a TSP that is connected to the same WSS

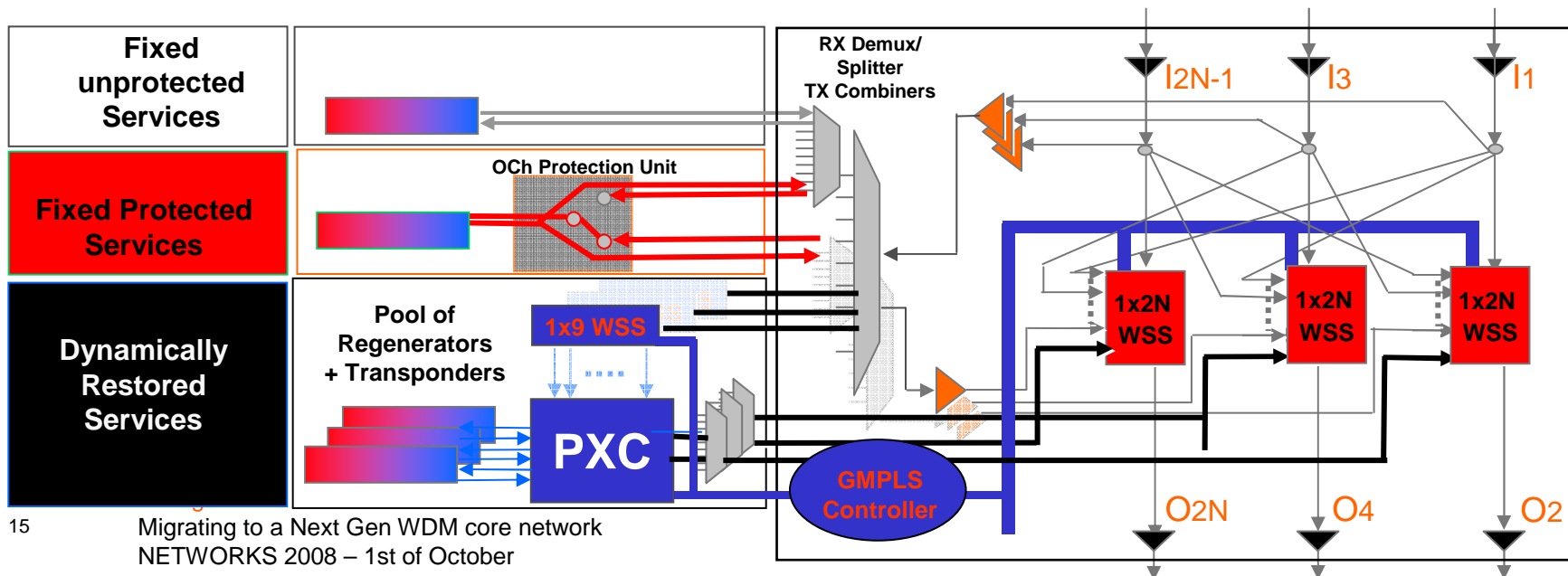


$$N_{WSS} = (AN + \sum_{i=1}^N [\text{Int}(Ch_i/9) + 1])$$

Ch_i = N.^{ber} of A/D channel on direction i

Alternative configuration

- **WSS based ROADM**
 - provide switching between trunks
 - Broadcast and select architecture
- Traditional Demux + couplers on each branch for fixed services (large part of the services)
 - Lowers the cost associated with channel multiplexing and demultiplexing
- GMPLS controlled RX WSS + PXC for a limited number of services
 - Directionless non blocking partial Tunability through PXC
 - PXC allows for Limiting the number of WSS
 - PXC size remains acceptable
 - Dynamicity :
 - Time to market
 - Increased reliability thanks to dynamic restoration



Conclusion

- **Transparency dramatically reduces the global network cost**
 - Transponders represents the biggest WDM cost centre
 - Complicates network Engineering
 - ➔ Planning tool needed to validate each path to be provisioned
- **Partitioning the network helps in reducing wavelength contention while releasing engineering constraints**
- **Implementing optical bypass (High speed transit) on secondary directions allows for significant CAPEX savings**
 - Leads to an operational complexity
 - Bad Network upgradeability
- **WSS adds flexibility and simplifies Engineering and planning activities**
 - Reduces OPEX
 - Allows for masking the channel to band mapping in the planning activities
 - Allows for additional savings which increase with the network load
- **Full tunability is required to migrate to a GMPLS agile network infrastructure**
 - Actual proposed configuration shall be optimized to reduce the number of WSS
 - Some more cost effective alternatives based on PXC or tunable filters may come out
 - Shall consider flexibility only for a subset of the services
- **With the target of improving network availability**