Challenges on new control services for transport networks

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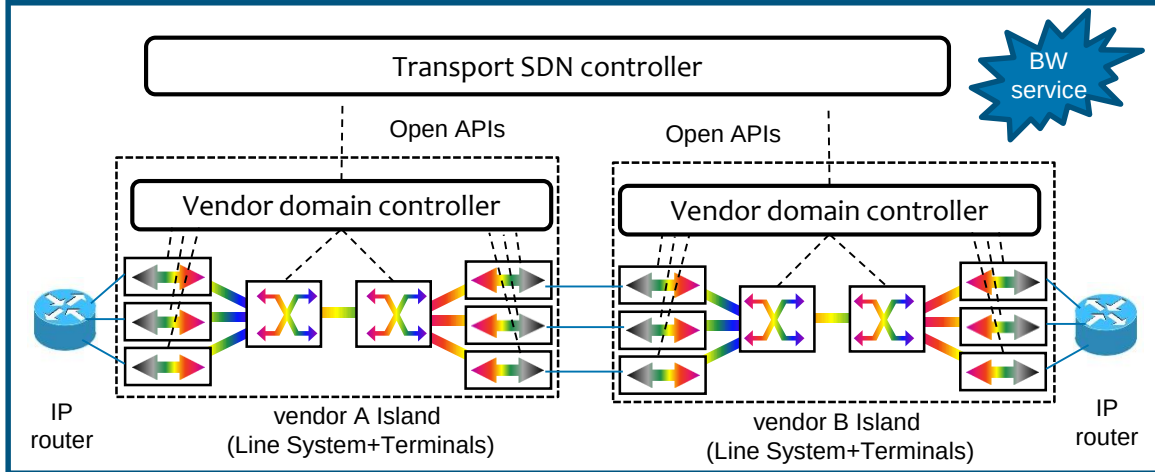
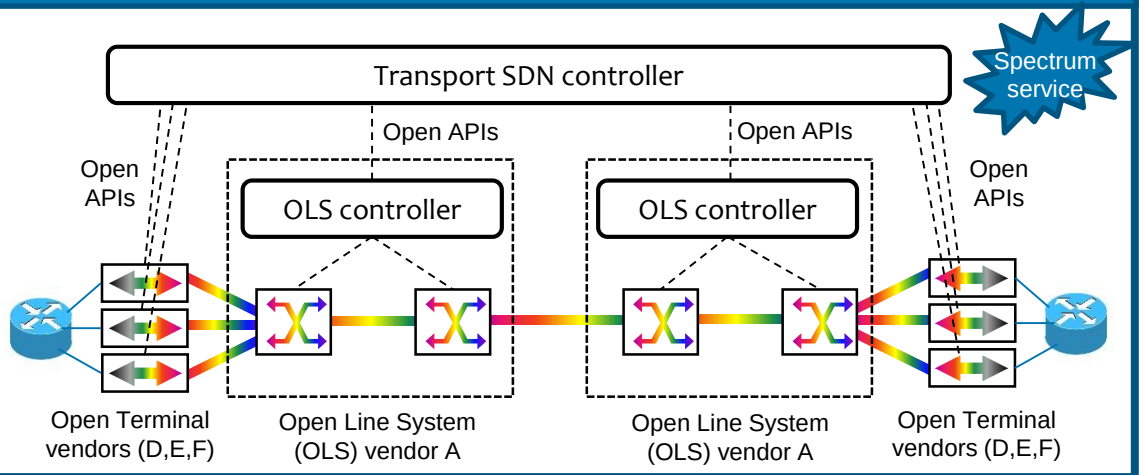
2nd Visions for Future Communications Summit, 27th, 28th November 2019

Evolution of optical networks: towards disaggregation

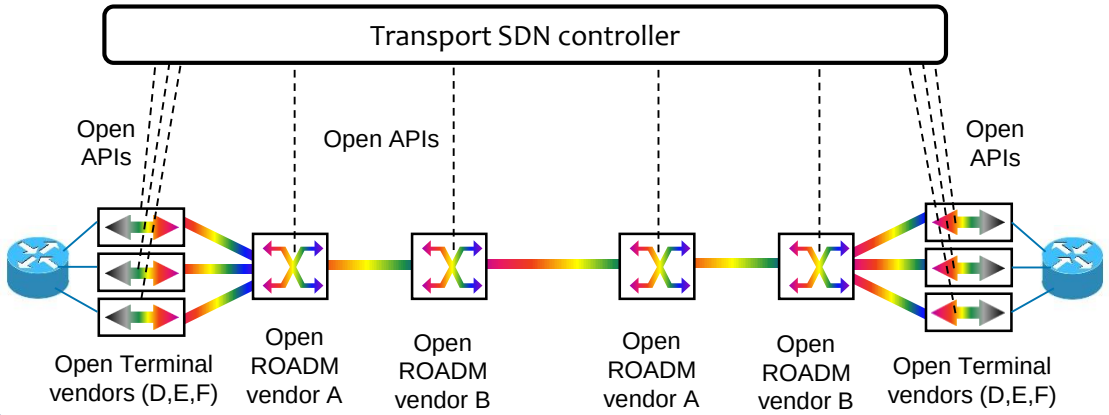
First disaggregation (2015)



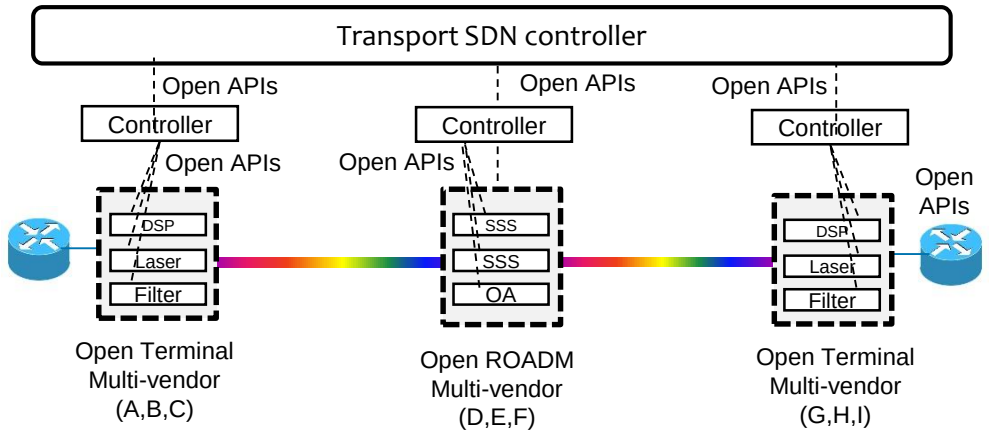
Partially disaggregated (~2020)



Fully disaggregated (open systems) (~2025)

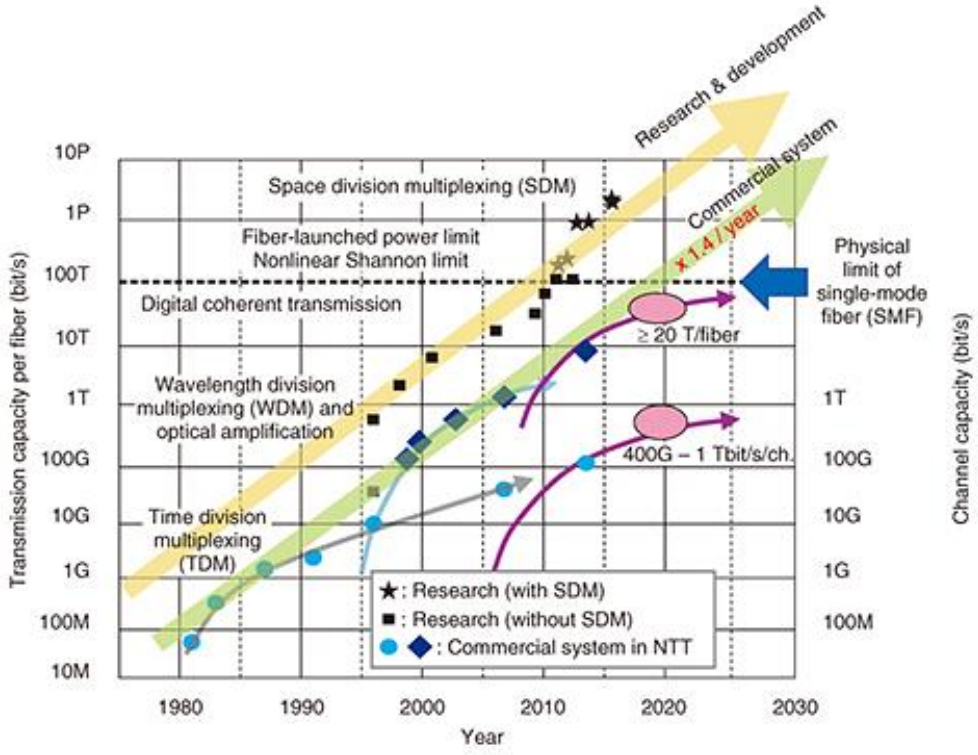


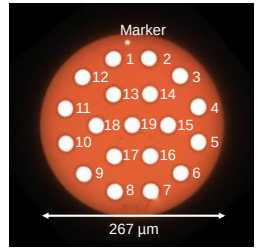
Fully disaggregated (open subsystems) (>2030)

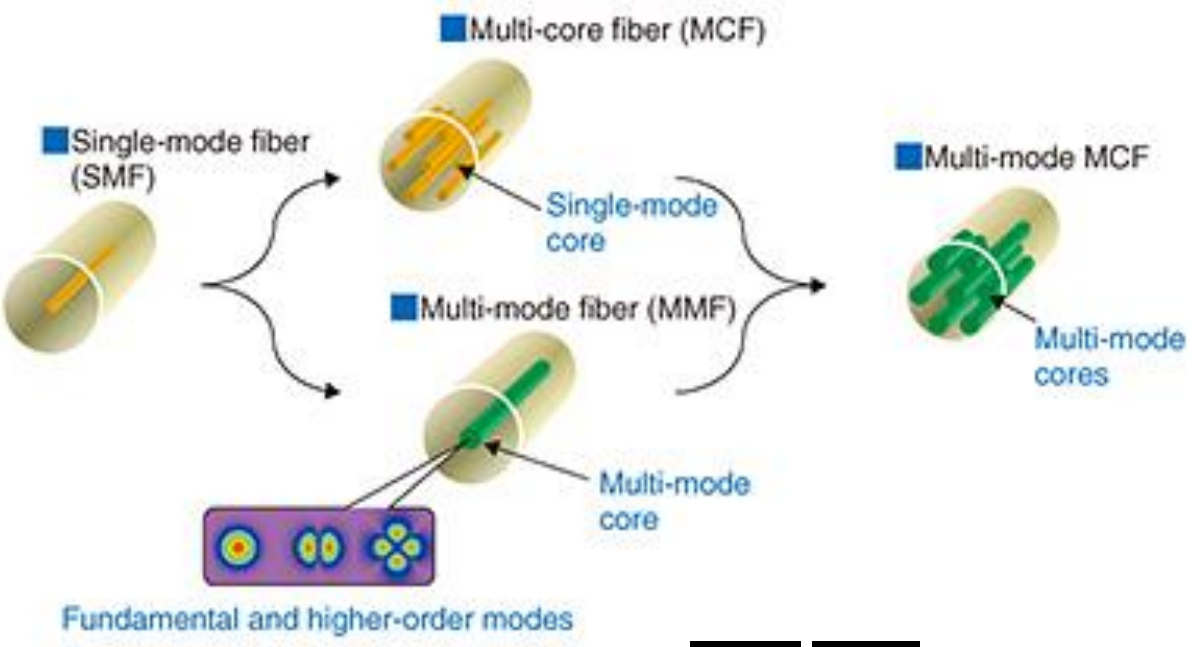


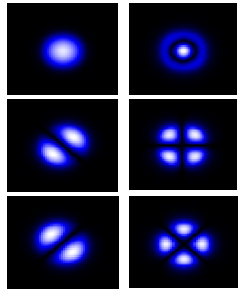
Evolution of the optical spectrum: towards virtually infinite spectrum

- Single-mode fibers have already reached it physical limit.









Yutaka Miyamoto and Ryutaro Kawamura, Space Division Multiplexing Optical Transmission Technology to Support the Evolution of High-capacity Optical Transport Networks, https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201706fa1.html

Challenge #1: Full programmability

- Fully optical disaggregation network are a clear use case for:
  - open interfaces
  - Programmability
- They require the adoption of unified and systematic information and data modelling for the optical systems and subsystems.
- Target optical systems and subsystems are particularly challenging to model due to the lack of agreed-upon hardware models:
  - Critical for an interoperable ecosystem, in spite of cross-vendor initiatives that do not cover advances in optical devices.
- Hard to reach consensus for OpenROADM, OpenConfig.

Challenge #2: Large scale network Telemetry and data analytics

- Optical transports networks suffer from physical layer impairments that degrade the quality of the optical analog signal.
- Failures can be generated by equipment malfunctioning or ageing, interferences due to new connections, or maintenance tasks.
- It is key to include support for large scale monitoring/telemetry from heterogenous optical systems/sybsystems to support SDN controller, enabling:
  - Local data collection points
  - Data analytics (e.g. AI) to recommend network reconfiguration actions.
  - Autonomous control loops for network continuous optimization.

Challenge #3: Infinite spectrum service management and virtualization

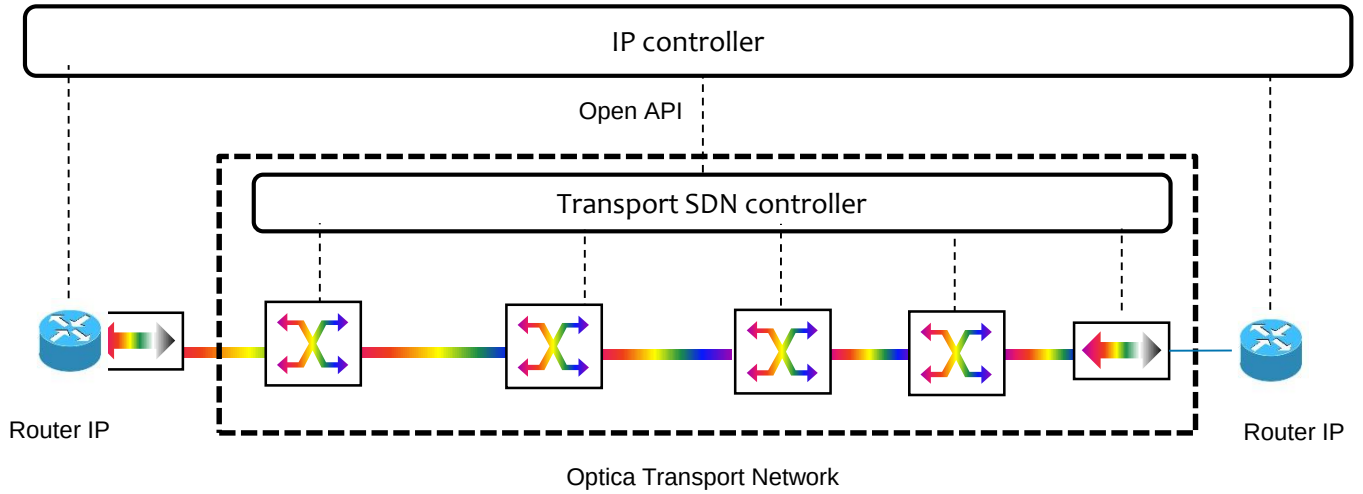
- Disaggregated optical networks are not just providing capacity services (in Gb/s) but also spectrum services (in GHz).
- On the other hand, the increase in the available bandwidth thanks to the spatial dimension (i.e., core and modes) justifies the adoption of network sharing and virtualization.
- It allows to generate new business opportunities and services similar to the radio spectrum:
  - The optical spectrum can be "licensed" to new actors that can access to the allocated portion of the spectrum using their own optical terminals.

Challenge #4: Novel SDN architectures ensuring reliability, security and robustness.

- From the control plane perspective, neither a fully distributed nor a fully centralized architecture fits for all use cases and scenarios:
  - e.g., centralized monitoring and telemetry does not scale.
- Fully disaggregated optical networks require the adoption of local network element controllers to distribute some control functions of the centralized SDN controller to the nodes, deploying hybrid approaches:
  - considering distributed elements with data analytics and local control loops
- Mechanisms for trusted services in order to ensure that the Transport SDN controllers in a multi-domain environment underlying optcal devices are all trusted entities that are operating as they should.

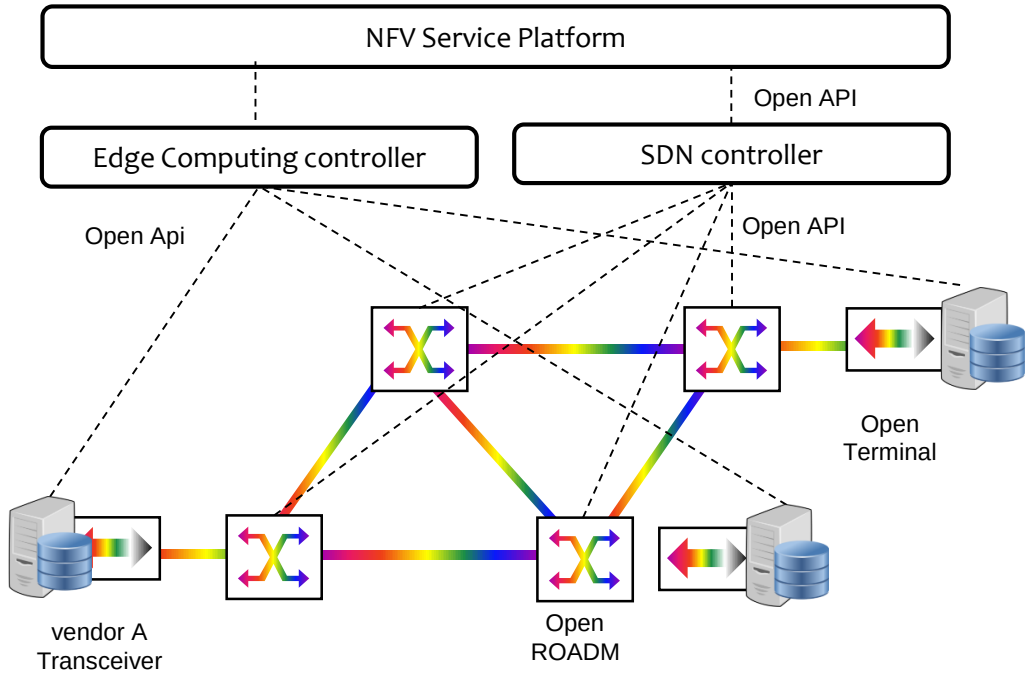
Challenge#5: Adaptive cross-layer connectivity service orchestration

- Optical transport networks must be seamless integrated with IP networks (packet) in order to provide a highly flexible connectivity infrastructure that can :
  - dynamically adapt to changing requirements of innovative applications (i.e., connectivity services automatically trigger optical connectivity services when required)
  - Support large-scale management of flows with dedicated QoS.
  - IP routers can also deploy integrated transponders and request spectrum services to the optical transport network.



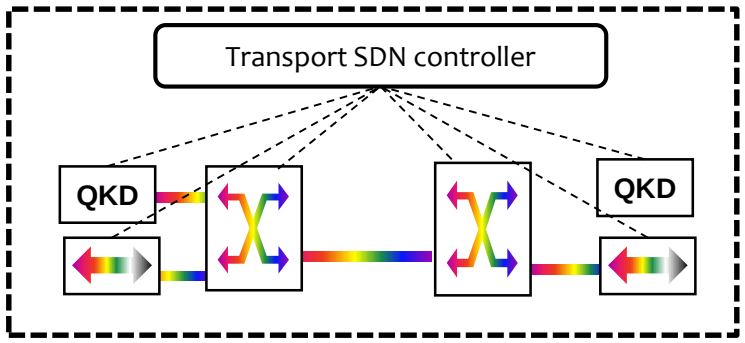
Challenge #6: Advanced orchestration of Edge computing and optical transport resources

- Computing resources are required to be distributed at the network edge towards a perceived zero latency
- Distributed edge computing nodes with optical interfaces requiring seamless and secure end-to-end orchestration between computing and transport resources.



Challenge #7: Integration of QKD and disagregated optical transport networks

- Quantum key distribution (QKD) devices are commercially available. It allows the creation of security keys at the ends of a quantum channel.
- The co-propogation of quantum signals with optical (WDM) signals is very difficult, since the optical transport networks were not designed to fulfill the requirements.
- Disaggregated optical transport networks and SDN programmability can provide a level of flexibility that allows to meet the requirements needed to transmit quantum-level signals.



Thank you!

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