

Optical Networking for Data Centres Network

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The EU-funded LIGHTNESS project

- Low latency and **hIGH** Throughput dynamic **NETwork** infrastructures for high performance datacentre interconnectS
- Consortium (industry and academia)
 - Interoute
 - **Coordinator**
 - Technical University of Eindhoven
 - Nextworks s.r.l
 - Barcelona Supercomputing Centre
 - University of Bristol
 - **Technical leader**
 - Universitat Politècnica de Catalunya
 - Infinera
 - University of California Davis



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The EU-funded LIGHTNESS project

- Main objectives:
 - Design and prototype ultra-high capacity transport networks for intra-Data Centres
 - Design and prototype high-scalable and strictly non-blocking OPS node
 - Design and prototype hybrid Top of the Rack (ToR) switch
 - Design and prototype a unified network control plane for dynamic and on-demand high bandwidth connectivity services provisioning

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Introduction

- Data centers (DCs) are growing in size to accommodate the ever-increasing demand for cloud services
- Volume of users and cloud applications, High Performance Computing, etc.
- Applications in DCs require cooperation of a large number of servers arranged in racks
- Massive workloads exchanged among intra/inter rack servers (east-west traffic)

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Some requirements for future DCs

- Dynamic resources allocation
 - Joint optimization of both IT and networks resources
- Virtualization techniques (e.g., for multi-tenant DCs)
- VM/service mobility (for load-balancing, optimised usage of servers, energy-efficiency)
- Redundancy for server-to-server paths for fault-tolerance (high availability)
- Quality of Services guarantees
- End-to-end latency
- Energy-efficient connectivity provisioning
- Monitoring for optimised performance
- Interface with Operator Network (e.g., GMPLS-based flexible optical network)

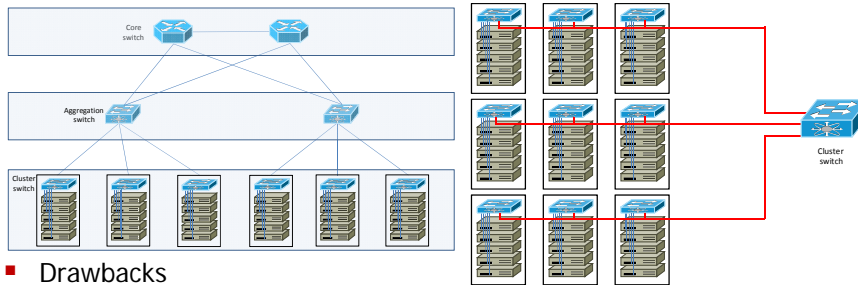
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Switching in data centres

- Currently data centres interconnects are based on commodity Ethernet/InfiniBand switch fabrics
- Multi-level hierarchical architectures



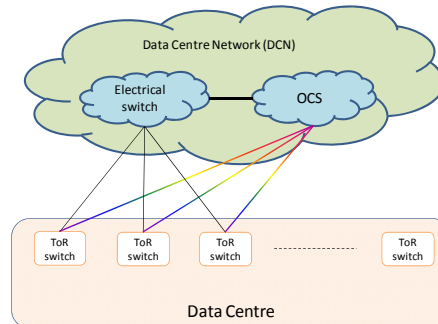
- Drawbacks
 - Scalability (high port-count required)
 - Latency
 - High power consumption

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Intra-DCs networks

- Interconnection network architecture for intra data centre network
 - Hybrid electrical/optical architecture (e.g., Helios*)
 - Use Optical Circuit Switching (OCS) to support long-lived traffic flows
 - MEMS-based optical switches



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*N. Farrington et al., "Helios: a hybrid electrical/optical switch architecture for modular data centers", Proc. of ACM SIGCOMM 2010

Intra-DCs networks

- Interconnection network architecture for intra data centre network
 - All-optical flat-architectures (fast switching)
 - Datacentre Optical Switch (DoS)*
 - Based on using AWGR and TWC
 - OSMOSIS optical switch**
 - Others***
 - Some challenges needs to be still faced
 - Power consumption
 - Scalability
 - Switch controller/Latency
 - Bandwidth provisioning flexibility
 - Fault tolerance

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* X. Ye et al., "DOS: A scalable optical switch for datacentres", *Proc. of 6th ACM/IEEE Symposium on Architectures for Networking and Communications Systems (ANCS), 2010*

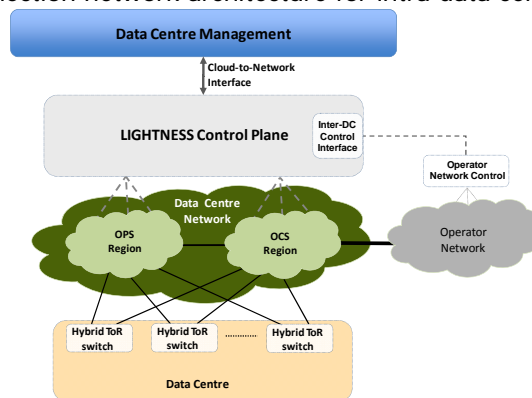
** R. Luijten et al., "Optical interconnection networks: The OSMOSIS project", *Proc. of 17th Annual Meeting of the IEEE Lasers and Electro-Optic Society, 2004*

*** C. Kachris, I. Tomkos, "A Survey on Optical Interconnects for Data Centers", *IEEE Communications Surveys & Tutorials, 2012*

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Novel architecture for intra-DCs networks

- Interconnection network architecture for intra data centre network



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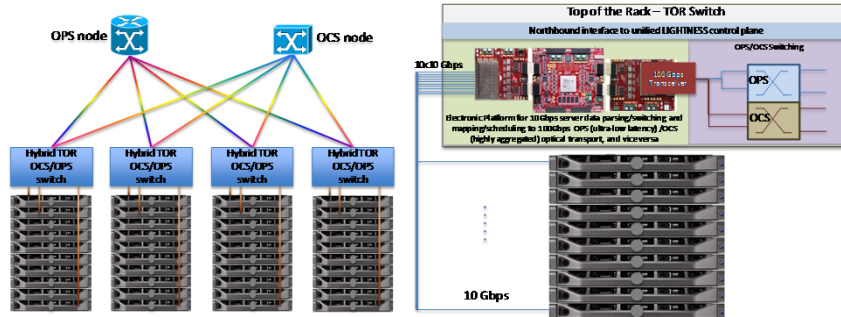


- Integrated hybrid optical switching solution:
 - Use Optical Circuit Switching (OCS) for long-lived traffic flows
 - Use of Optical Packet Switching (OPS) for bursty short-lived traffic flows

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Novel architecture for intra-DCs data plane

- Interconnection network architecture for intra data centre network



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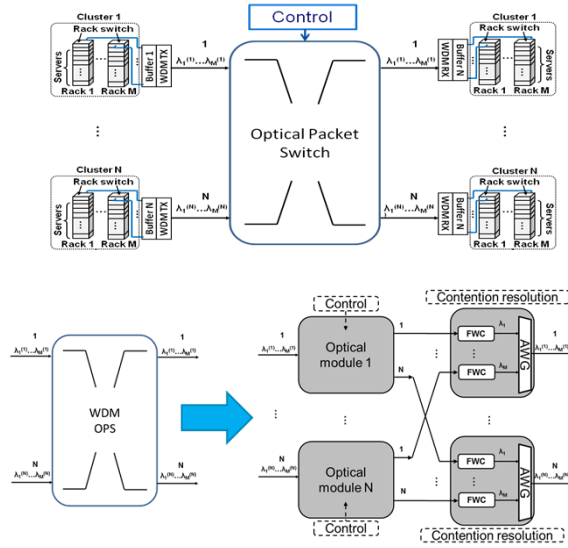
OPS paradigm for intra-DCs: some benefits

- Transparency
 - Data rates, data formats, packet formats transparency
- Throughput and Scalability
 - A large number of input/output ports
- Low Latency
 - Nanoseconds processing time
 - Fast switching of small/large packets
- Low Power Operation
 - No Optical-Electrical-Optical conversion

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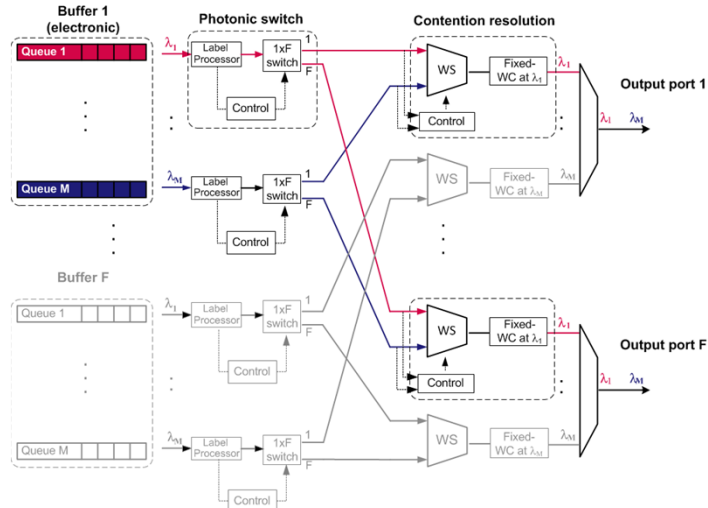
OPS paradigm for intra-DCs: some benefits



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OPS node for intra-DCs*



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* S. Di Lucente et al., "Scaling Low-Latency Optical Packet Switches to a Thousand Ports", IEEE/OSA JOCN, 2012

OPS node features

- Modular WDM OPS architecture based on 1xF photonic switches (PS)
- Contention resolution blocks (CRB) at each output based on fixed wavelength conversion
- Each PS operates independently from the others
- Each CRB operates independently from the others

- High bandwidth
- Highly distributed control
- Low latency
- Low losses

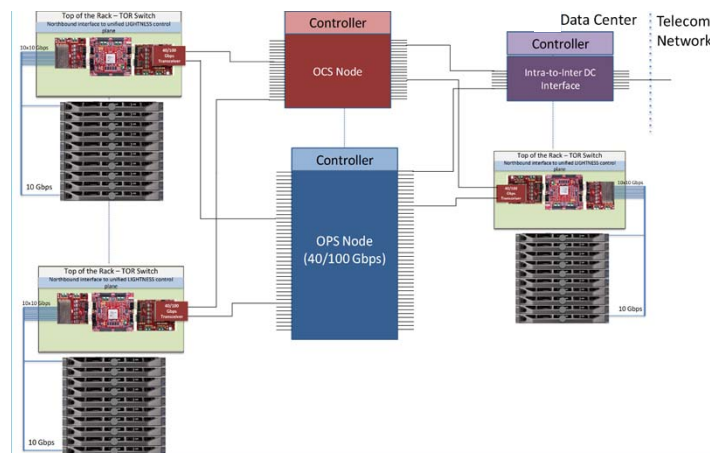
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Novel architecture for intra-DCs networks

- Interconnection network architecture for intra data centre network
 - Hybrid ToR switches (OCS/OPS)



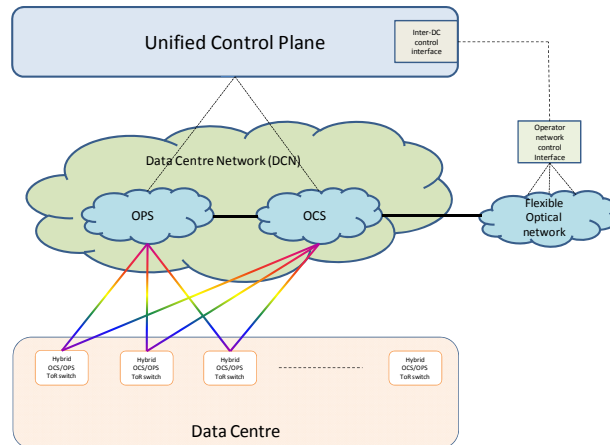
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DCN resources management

- Introduction of a unified control plane to efficiently manage the DCN resources



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Conclusions

- Optical switching technology will be adopted inside DCs
- Hybrid optical switching technologies to provide transport services tailored to the specific requirements in terms of latency, throughput
- Control Plane technologies:
 - Efficient data centres resources management
 - Energy-aware bandwidth provisioning
 - Fault tolerance
 - QoS guarantees

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