WaveCube: A Scalable, Fault-Tolerant, High-Performance Optical Data Center Architecture

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Overview

- Past Optical DCNs and drawbacks
- Devices used in DCNs and drawbacks
- Wavecube Architecture
- Wavelength Assignment
- Advantages

I shall be using the paper for certain illustrations

Past Electrical/Optical DCNs and drawbacks

Electrical include Fattree, BCube, and VL2

Optical include c-Through, Helios, OSA, and Mordia

They have drawbacks in three major metrics

- Electrical have the problem of wiring and optimal usage given the traffic patterns
- Optical have Scalability issues due to the devices used, Performance due to lower Fan in/out optical circuits (between ToRs). All of them have a single point of failure (mordia has ring topology, which will be disrupted by a single node failure)

Devices used in DCNs and drawbacks

MEMS: Micro-Electro-Mechanical-System, used in most of the optical networks and has physical rotating mirrors with a overall latency of 10ms (High!!). Has its drawbacks given its architecture

WSS and WDM are other important devices

Majority of the previous DCNs use multistage MEMS for increase in conenctivity but it has its drawbacks

- Low Port density - bottleneck of scalability
- Cost
- Latency cumulation and signal loss

WaveCube is a MEMS free architecture to avoid all the problems.

Wavecube Architecture

- WaveCube Topology
- Multi-pathing -> high fault-tolerance
- Dynamic Link Bandwidth
- Optimization with above two properties
  - Flow scheduling
  - Bandwidth scheduling

Wavelength Assignment

- Optimal Wavelength Assignment
- Optimized Wavelength Adjustment

Both of them are NP hard problems solved using LP. First one is similar to graph colouring problem and second one is 0-1 integer linear program which was proved to be NP-hard

Claims

- WaveCube outperforms previous optical DCNs by up to 400% and delivers network bisection bandwidth that is 70%-85% of an ideal non-blocking network under both realistic and synthetic traffic patterns
- WaveCube's performance degrades gracefully under failures—it drops 20% even with 20% links cut.
- WaveCube also holds promise in practice—its wiring complexityis orders of magnitude lower than Fattree, BCube and c-Through at large scale, and its power consumption is 35% of them.

It is fault-tolerant since there is no single point of failure and multiple node-disjoint paths exist between any pair of ToRs. WaveCube delivers high performance by exploiting multi-pathing and dynamic link bandwidth.