Behavior Analysis of DC Networks:
Failure Resiliency and Bandwidth Efficiency

Vahid Asghari and Mohamed Cheriet

Green-ICT Project

Introduction

- Data Centers (DCs) are important in today's life!
  - In most of the cities, our life relies on the functioning and availability of one or multiple DCs.
  - Governmental or private Services such as E-gov, E-health, E-banking

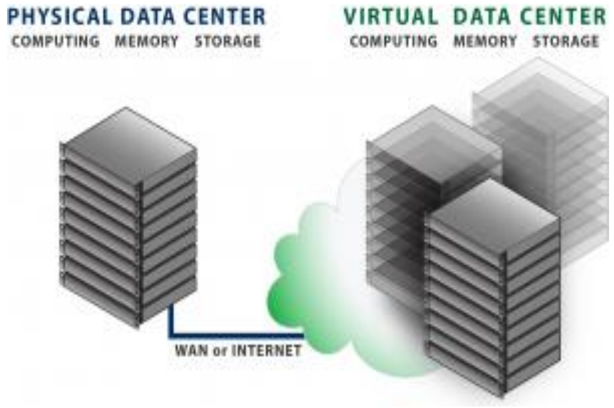
Problem Statement and Issues

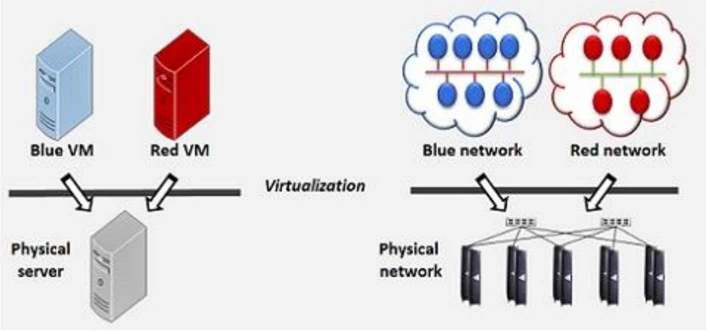
- **Failure resiliency is important.**
  - Resiliency is the ability of a server, storage system, or an entire DC, to recover quickly and continue operating even when there has been an equipment failure, power outage or other disruption.
  - In Time-sensitive businesses, Hardware or Software failures mean lost money and loads of frustration.

Objectives and Motivations

› **Having an efficient resource utilization and management is important.**

- DCs require a huge amount of resources!
- Engaging to almost any provided services!
- DCs have evolved from a passive element of compute infrastructure to become an active part of many ICT solutions, e.g., Virtualization Tech.



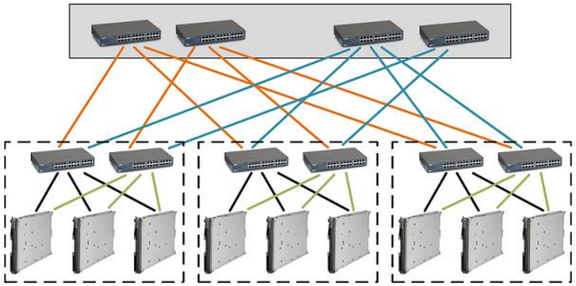


➢ **Goal: Failure resilience with efficient resource utilization and management.**

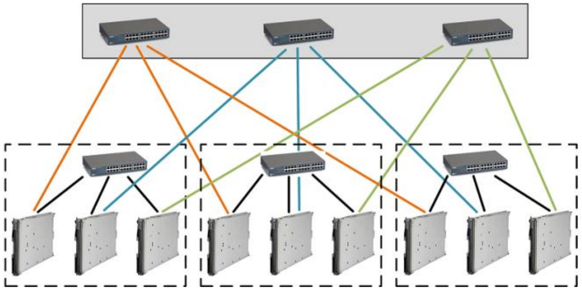
Literature Review

- Standard DC Topologies
  - FatTree, Bcube and MDCube and others.
  - The topology features, e.g. Number of possible paths between nodes, available Interconnected BW between nodes.
- Failure Analysis
  - Empirical analysis
  - Probabilistic approach, e.g., using Weibull distribution.

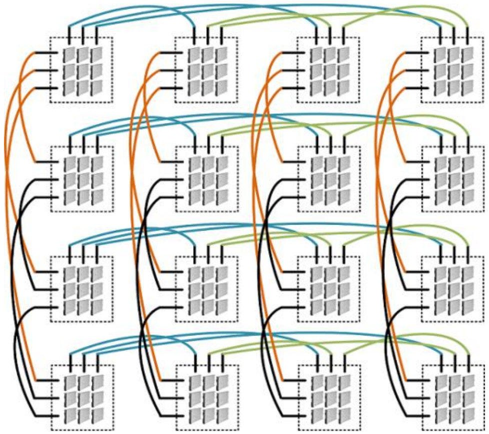
FatTree



BCube



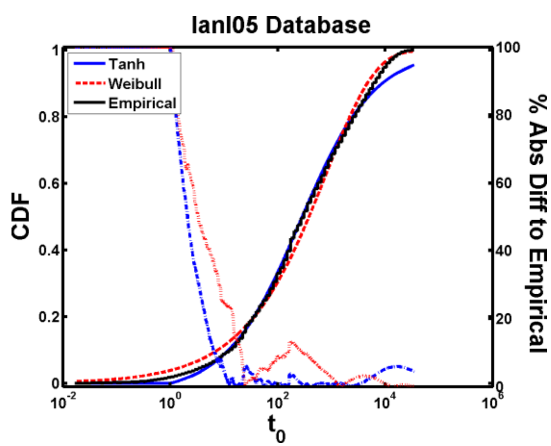
MDCube

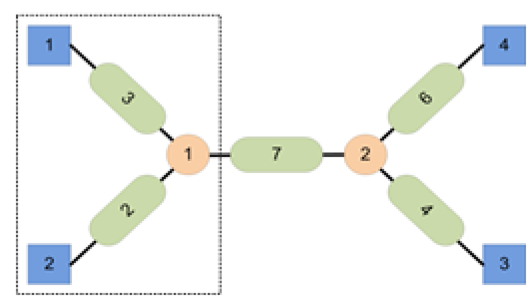


Methodology and Contributions

- First step, Study the impact of DC components' failure on the life-long operation
  - Using **Tanh** characteristic function to model the failure behavior of each component type.
- Failure Characteristics Modeling
  - Individual component failure profiling and Propose a Tanh-based Distribution function for Failure analysis

Ex: Server





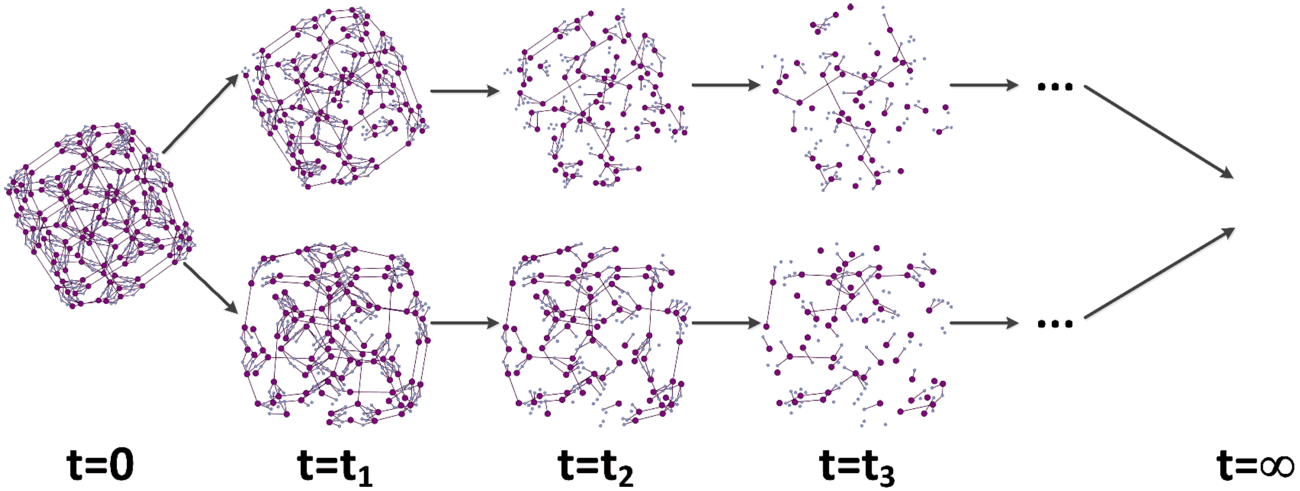
Failure Analysis

› We only consider the failure behavior of the main components of network topology.

› This a life-long failure analysis.

› **Performance Metrics:**

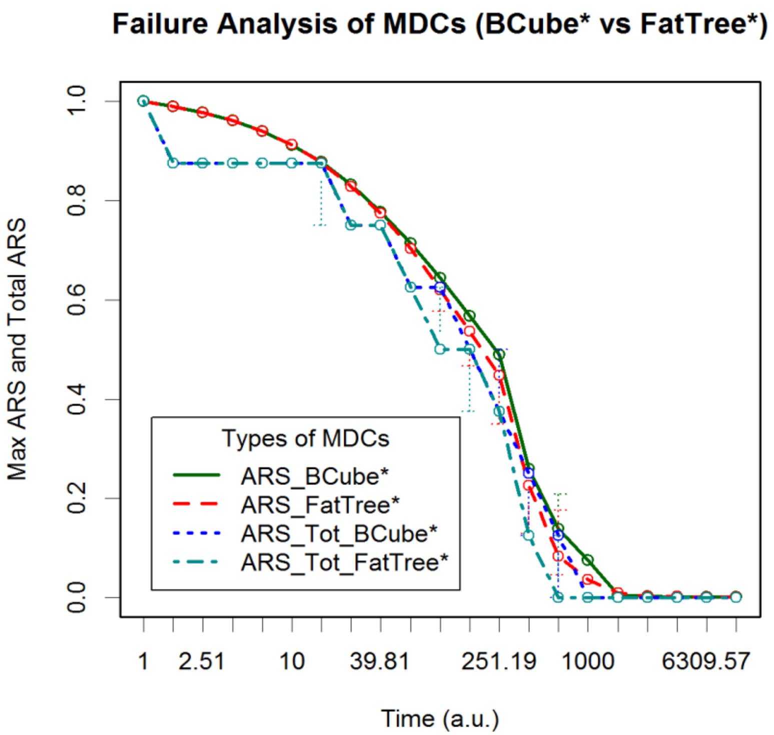
- **Metrics:** Relative Size (RS) vs Absolute Relative Size (ARS)

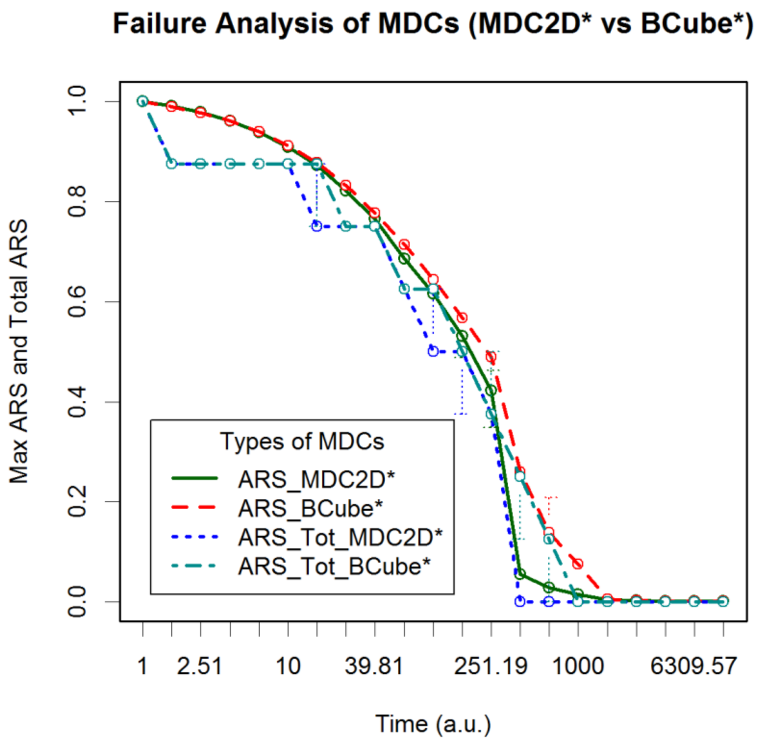


- MDCube2D with 256 servers and 128 switches.

Results: Failure Analysis

› Comparison between different topologies





Methodology and Contributions

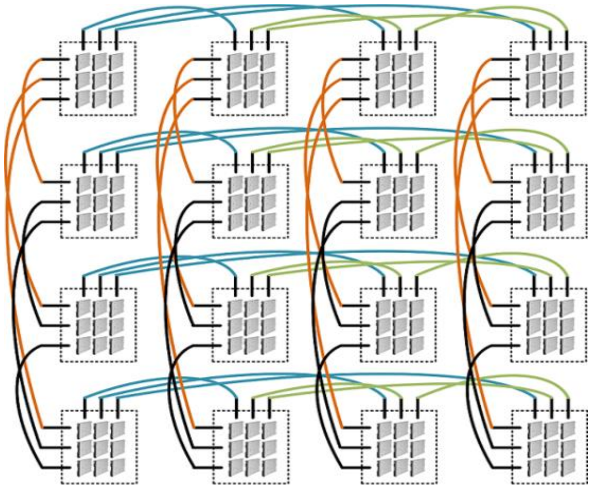
› Second Step:

- **Goal:** Investigating a group of DC network topologies with capability of **Not only** failure-resiliency, **But** to provide bandwidth efficiency required as a function of the active traffic.

Literature Review

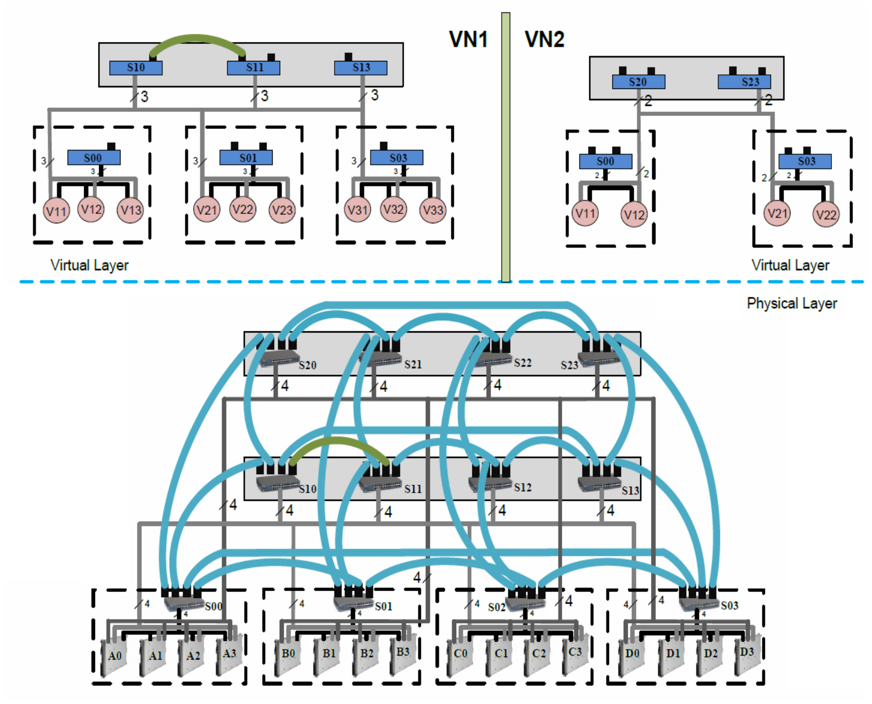
- Modified Topologies:
  - Classic topology issues, e.g. scalability, design restrictions
  - E.g., Modular DCs
    - COTS (commercial off the shelf) Switches
    - Using High-speed interfaces

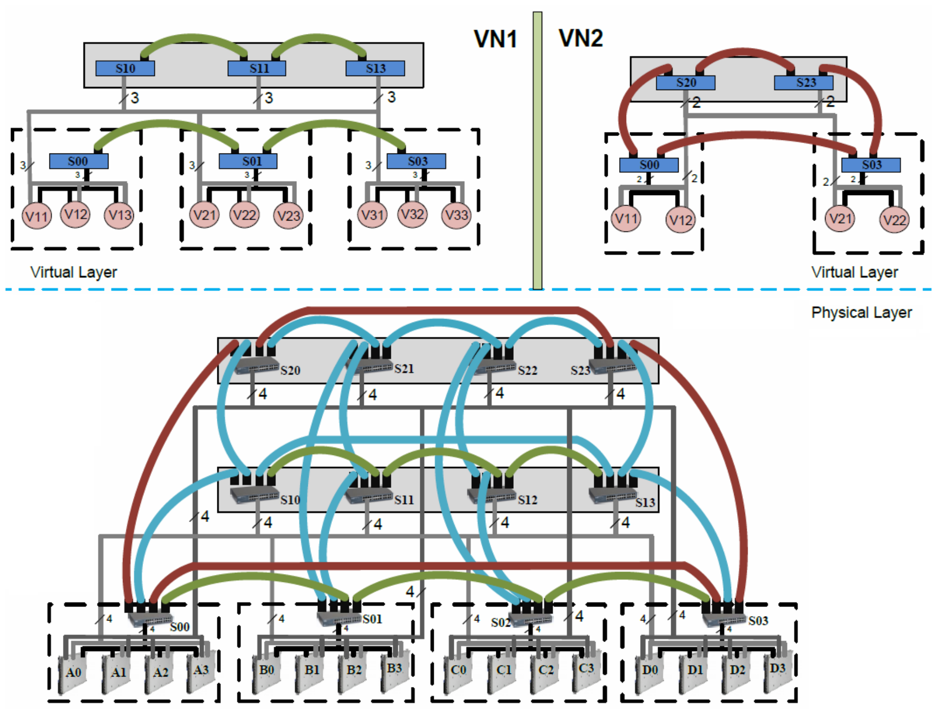
MDCube



Objective and Motivation

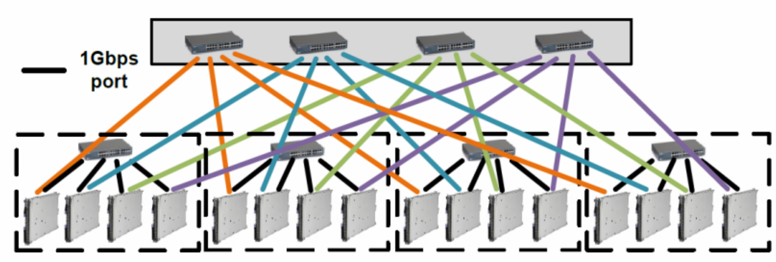
- Concept of Topology-on-Demand (ToD)
  - Handling temporal changes in the required topology.
  - **BW-on-Demand**: Handling temporal changes in the required bandwidth

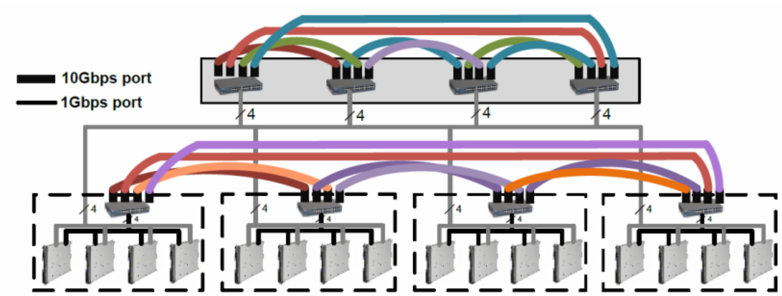


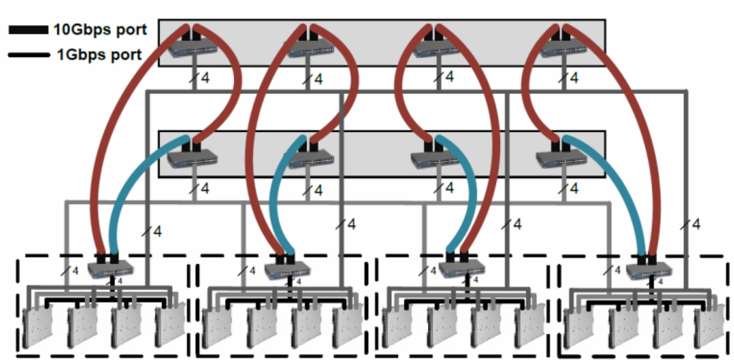


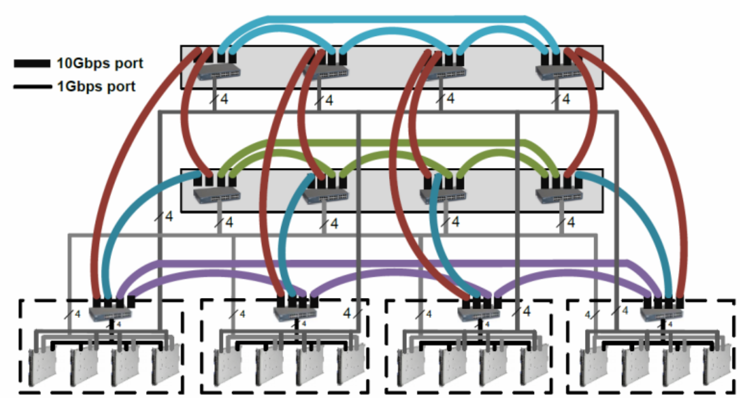
Methodology and Contributions

- Modified BCube Topology:
  - **Goal:** Providing Dynamic Bandwidth Efficiency
  - Using high-speed interfaces, Various forms of Horizontally, Vertically, and Hybrid.









Some Results

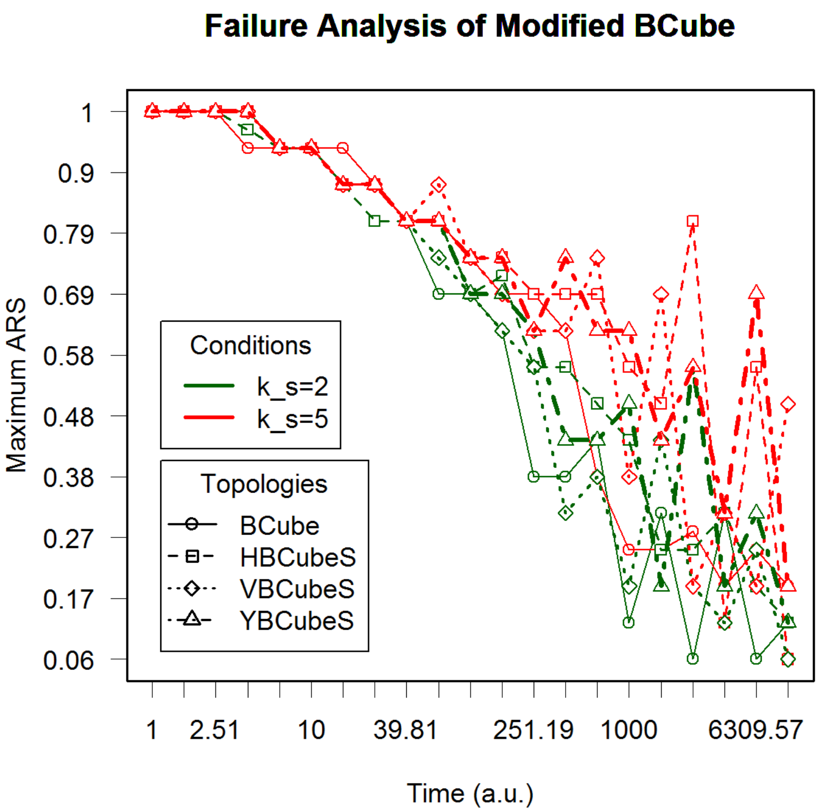
- Structural performance analysis:
  - A significant increase in the achievable IBW values between the switch nodes.
  - Confirms the effectiveness of the proposed modified topology.

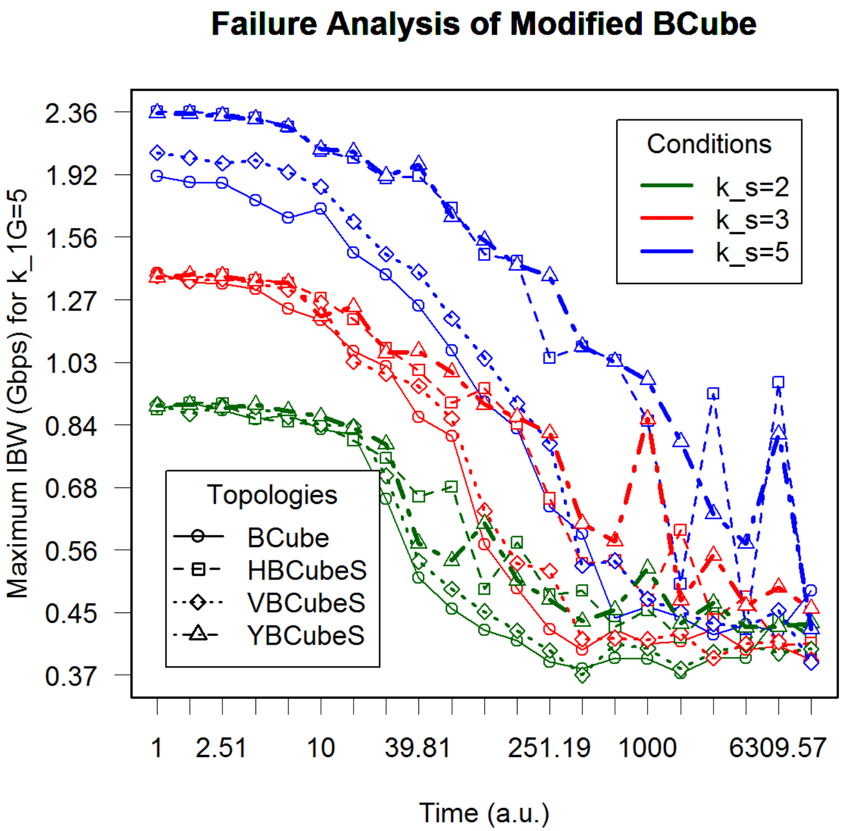
MINIMUM MAXIMAL MULTIPLE-PATH BANDWIDTH IN BCUBE TOPOLOGIES.

Between	Classic BCube	Horizontal BCube	Vertical BCube	Hybrid BCube
srv $\leftarrow \cdots \rightarrow$ srv	$\mathrm{k_s}\ B_{\mathrm{1G}}$	$\mathrm{k_s}\ B_{\mathrm{1G}}$	$\mathrm{k_s}\ B_{\mathrm{1G}}$	$\mathrm{k_s}\ B_{\mathrm{1G}}$
swc $\leftarrow \cdots \rightarrow$ swc	$\mathrm{k_{1G}}\ B_{\mathrm{1G}}$	$\mathrm{k_{10G}}\ B_{\mathrm{10G}}$ $+\mathrm{k_{1G}}\ B_{\mathrm{1G}}$	$\mathrm{k_{10G}}\ B_{\mathrm{10G}}$ $+(\mathrm{k_s}-1)(\mathrm{k_{1G}}-1)\ B_{\mathrm{1G}}$	$\mathrm{k_{10G}}\ B_{\mathrm{10G}} + \mathrm{k_{1G}}\ B_{\mathrm{1G}}$ $+(\mathrm{k_s}-1)(\mathrm{k_{1G}}-1)\ B_{\mathrm{1G}}$
srv $\leftarrow \cdots \rightarrow$ swc	$\mathrm{k_s}\ B_{\mathrm{1G}}$	$\mathrm{k_s}\ B_{\mathrm{1G}}$	$\mathrm{k_s}\ B_{\mathrm{1G}}$	$\mathrm{k_s}\ B_{\mathrm{1G}}$

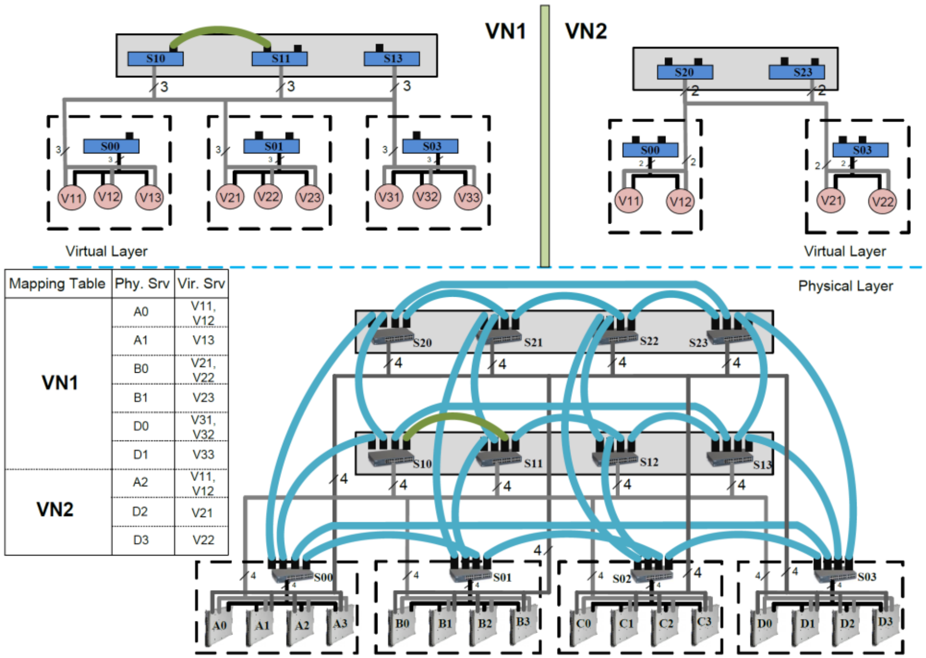
Results: Failure and IBW Analysis

› Performance improvement for Horizontal- and Hybrid-BCube topologies.

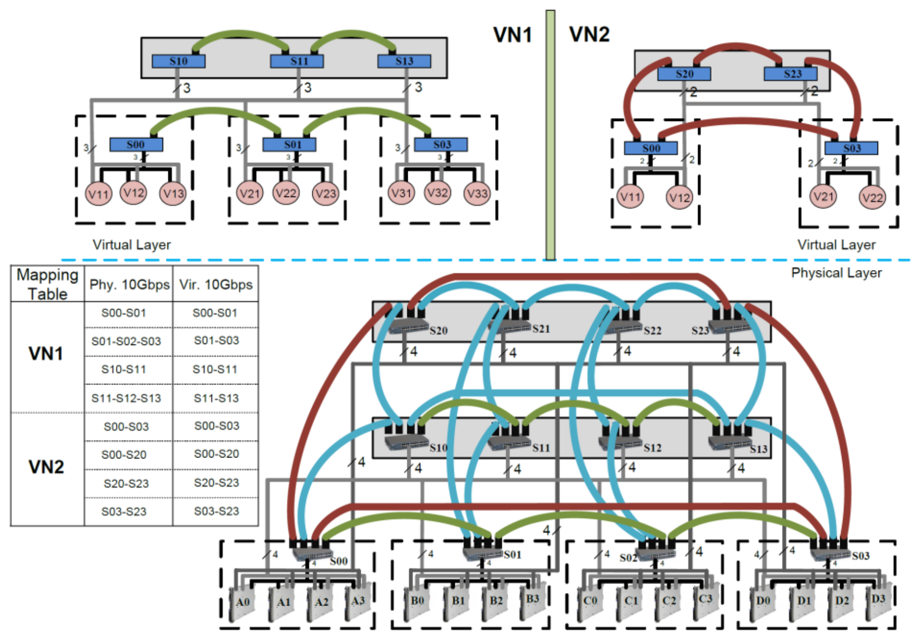




BW-on-Demand



Mapping Table	Phy. Srv	Vir. Srv
VN1	A0	V11, V12
	A1	V13
	B0	V21, V22
	B1	V23
	D0	V31, V32
	D1	V33
VN2	A2	V11, V12
	D2	V21
	D3	V22



Mapping Table	Phy. 10Gbps	Vir. 10Gbps
VN1	S00-S01	S00-S01
	S01-S02-S03	S01-S03
	S10-S11	S10-S11
	S11-S12-S13	S11-S13
VN2	S00-S03	S00-S03
	S00-S20	S00-S20
	S20-S23	S20-S23
	S03-S23	S03-S23

– Thank you.