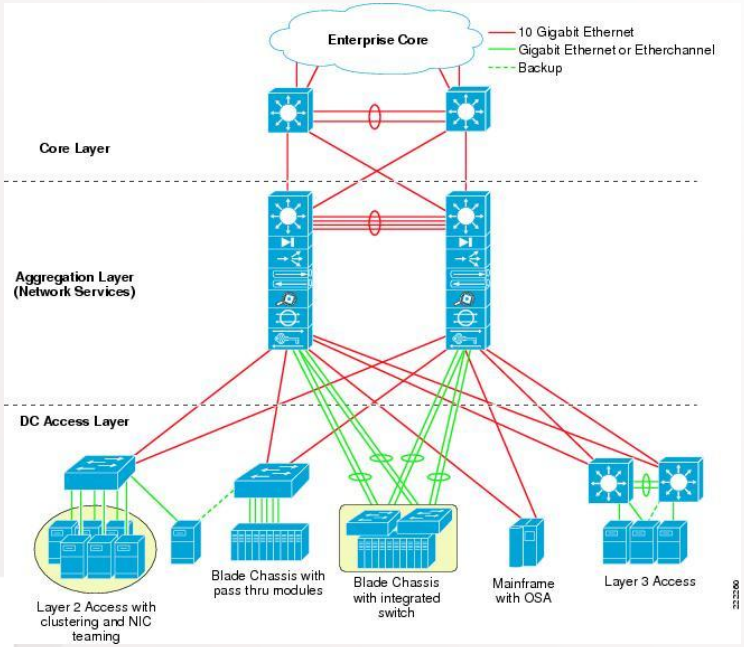
Simulating DataCenter Network Topologies



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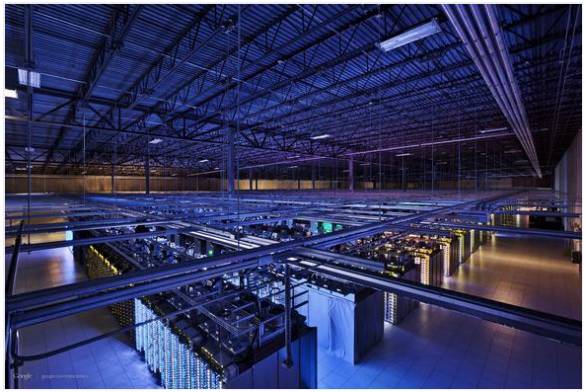
Agenda

- Data Center Networks (DCN)
- Project Proposal (Our Work)
- Network Topologies & Properties
- Simulation using NS-3
- Conclusion and Future Work

Data Center Networks(DCN)

- A pool of interconnected resources that serve the internet.
- Recent years have seen huge growth in data transfer especially due to multimedia, big-data and high speed internet.
- Projected growth is ~23% per year
- Managing data is inevitable and extremely challenging.



A Google Data Center

Courtesy : http://www.cse.wustl.edu/~jain/cse570-13/ftp/m_03dct.pdf

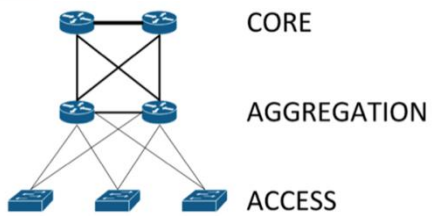
Cisco Global Cloud Index, 2013-2018

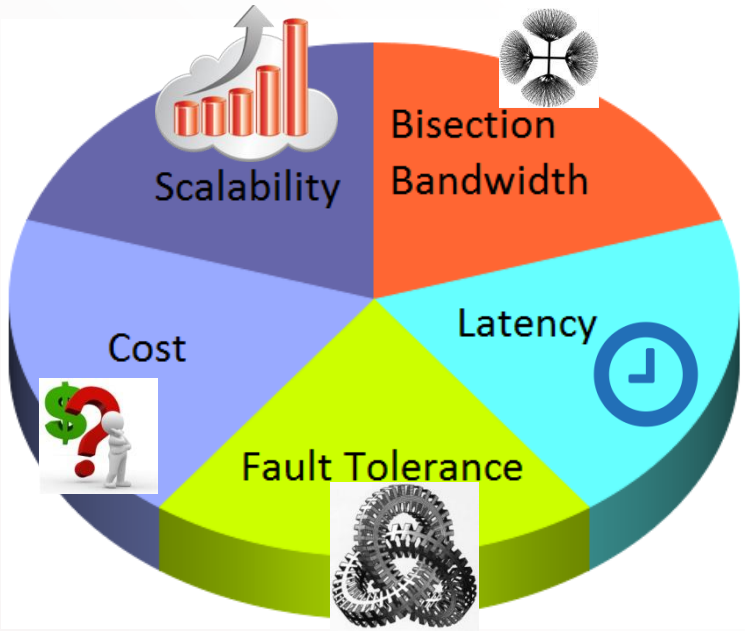
DCN – Overview & Challenges

- Usually consists of three layers – *core*, *aggregation* and *access*

- Nodes are connected using a interconnection network topology like *FatTree*, *Flattened Butterfly or DCell*

- *Topology* is an important factor responsible for the challenges





Important Challenges

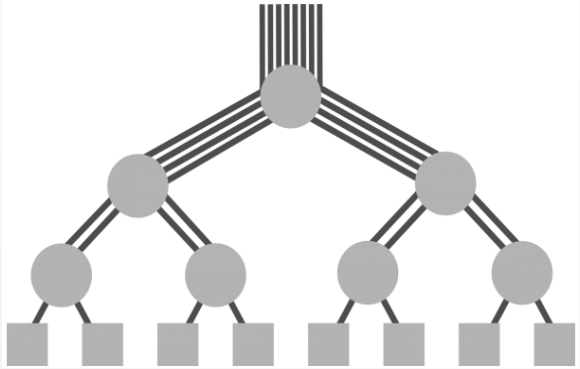
Project Proposal (Our Work)

- *Study and evaluate* existing data center topologies (FatTree, Flattened Butterfly, BCube, Dcell, FiConn and HyScale).

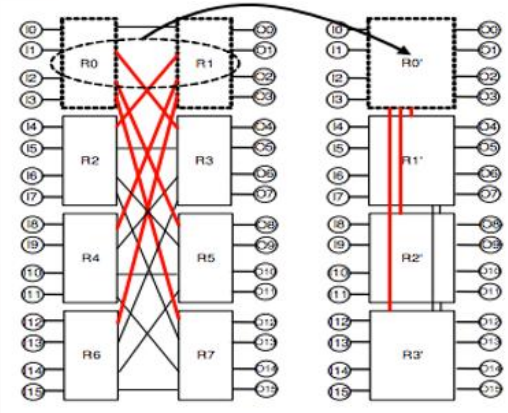
- *Simulate on ns-3* tool under various traffic scenarios.

- *Design and simulation* of a new-topology.

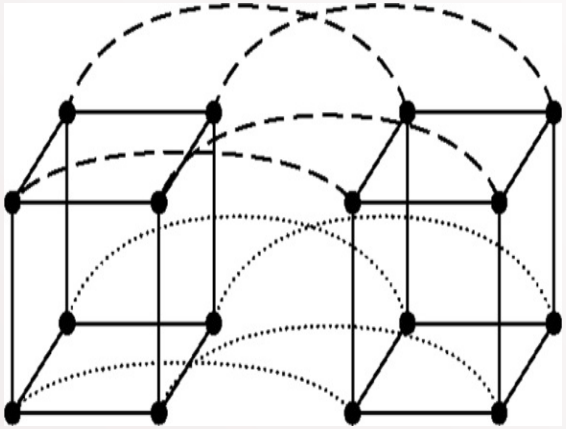
Important Topologies



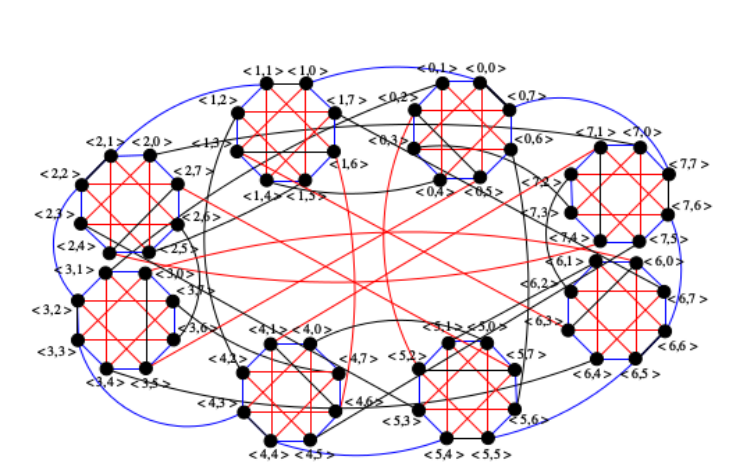
- *FatTree*



- *Flattened ButterFly*



- *BCube*

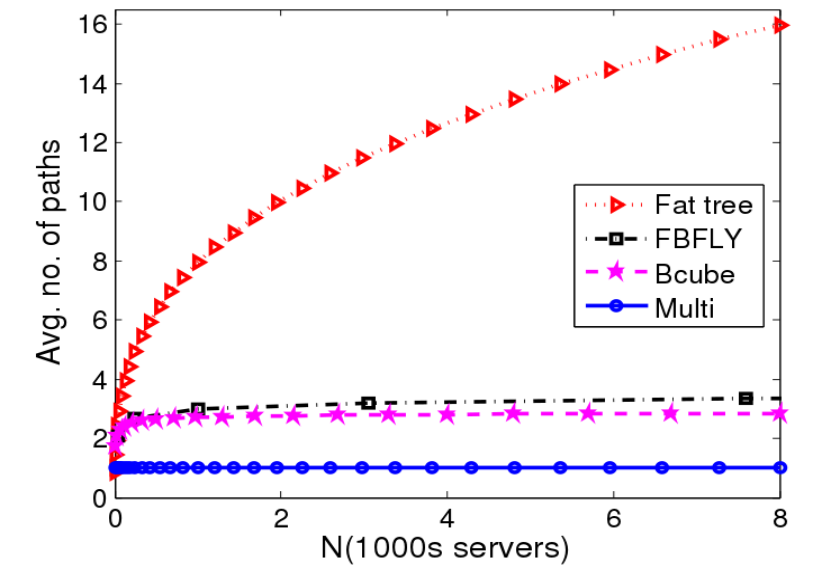


- *HyScale*

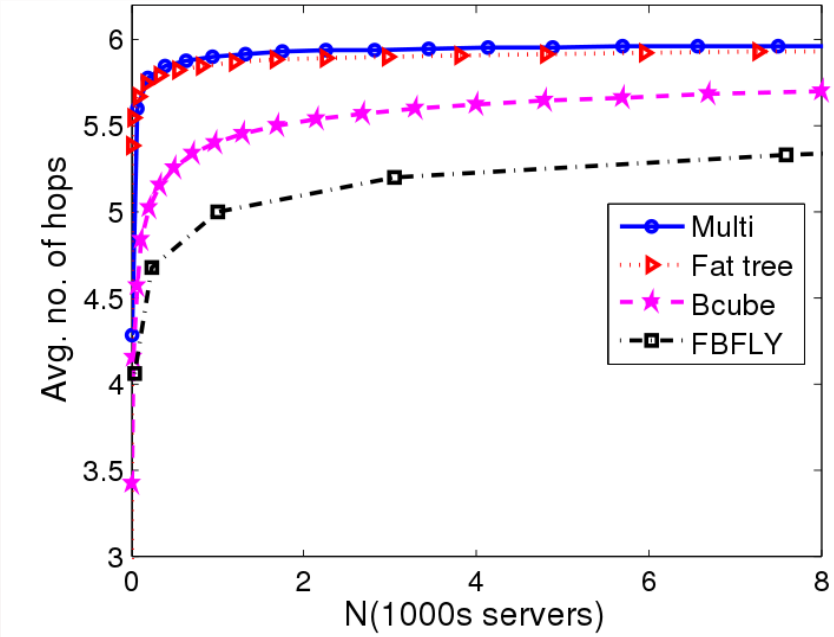
Topologies – Important Properties

Topology	*Servers*	*Diameter*
FatTree	$n^3/4$ (n= number of groups/pods)	*k+1*
BCube	n^{k+1} (n = number of servers connected in basic unit, k= recursion depth)	*4*
HyScale	aT^{k+1} (a = number of servers connected at each node, k= recursion depth, T = number of nodes in base model)	*4k+2*

Topologies – A Comparision



- ***Average disjoint paths***

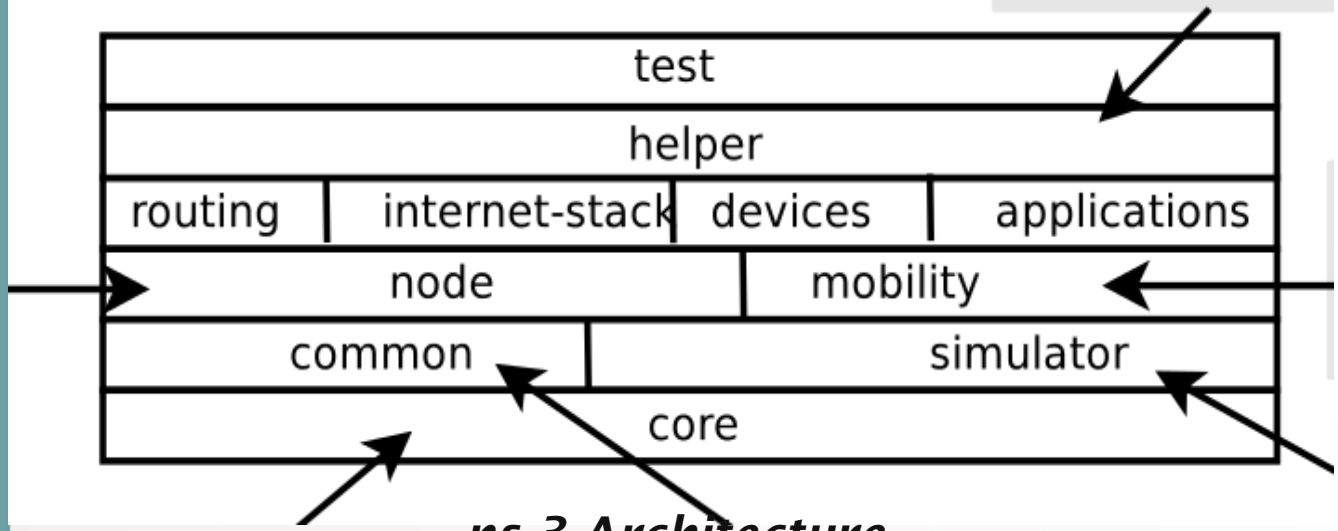


- ***Average Hop Count***

Ns-3 : Network Simulator

- Simulation tool that supports scripts in C++ or python.
- Uses *Netanim* as a visualizer, but other tools can be used as well
- Direct support for pcap trace files, xml outputs and plotting (*gnuplot*)
- Conceptual design still the same as ns-2, but capability less that ns-2

Ns-3: Architecture and an Example



ns-3 Architecture

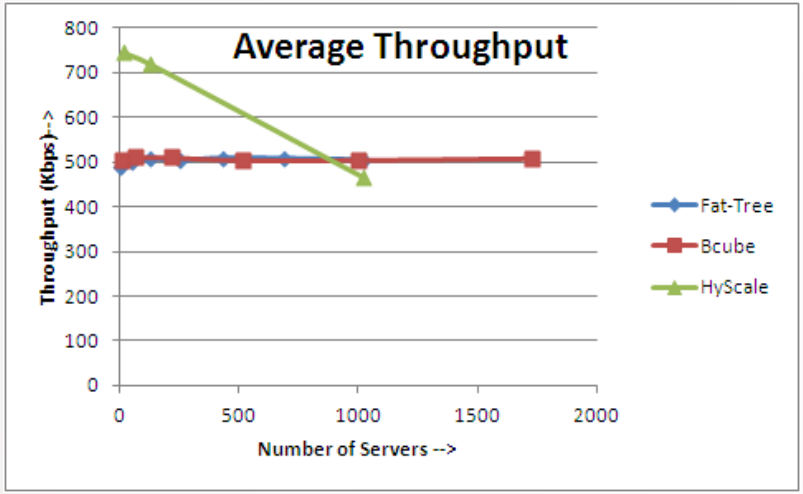
```
//
// UDPClient   10.1.1.0                                  UDPServer
//  n0 -------------- n1   n2   n3   n4
//      point-to-point  |    |    |    |
//  start:2s            ================
//  end:5s                 LAN 10.1.2.0   start:1s
//                                        end:5s
```

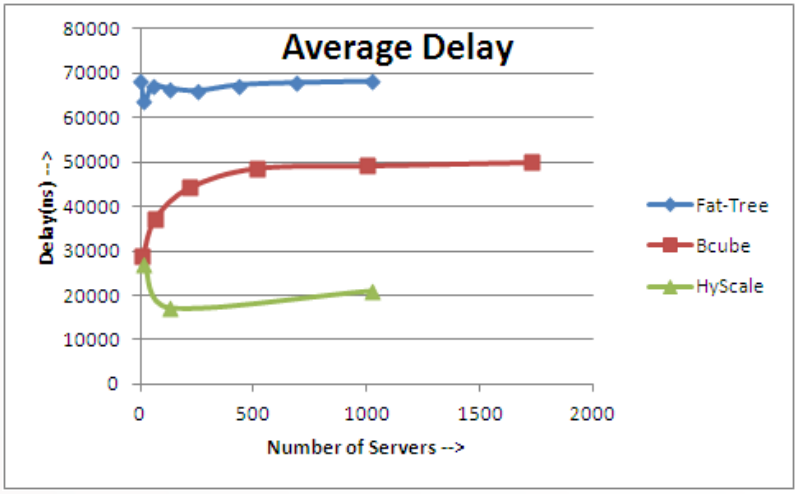
An Example Topology

DCN Simulation Setup

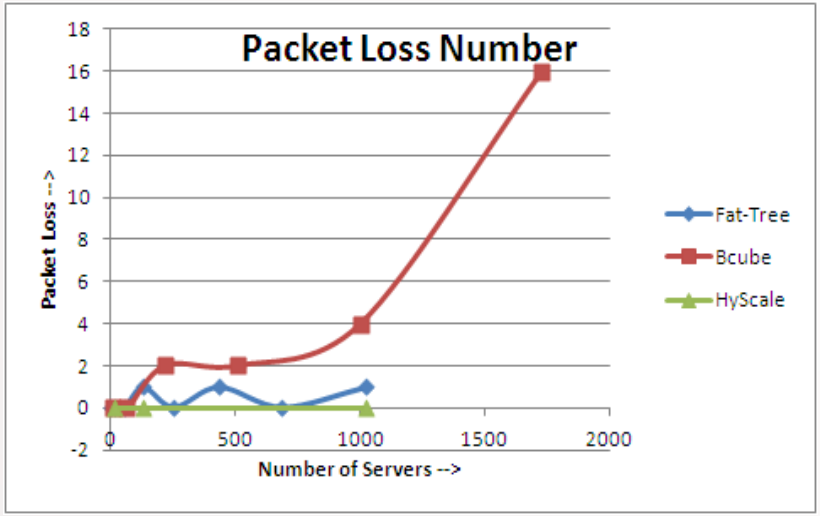
Simulation Parameters	***Fat-Tree***	***BCube***	***HyScale***
Simulation Time	100sec	100sec	100sec
PacketSize	1024bytes	1024bytes	1024bytes
DataRates between switches	1Mbps	1Mbps	1Mbps
DataRates between switches and hosts	1000Mbps	1000Mbps	1000Mbps
Communication Pattern	Random selection of two hosts and sending data between them	Random selection of two hosts and sending data between them	Random selection of two hosts and sending data between them
Traffic Flow Pattern	Exponential Random	Exponential Random	Exponential Random
Routing Protocol	Nix-vector(ns-3)	Nix-vector(ns-3)	Nix-vector(ns-3)
Animator	NetAnim	NetAnim	NetAnim
Variable parameter(refer to Slide 7)	*n varied (2-12)*	*k=2, n varied(2-12)*	*a=2, T=8, k varied from (1-3)*

DCN Simulation: Results





Observed Average Throughput and Average Delay with exponential random traffic pattern.



Observed Packet loss with exponential random traffic pattern.

DCN Simulation: Observations

- Simulated *Fat-Tree* and *BCube topologies* based on existing implementations.
- Analysis and interpretation of results are still in progress.
- Using *ns-3* tool seemed complex since it's architecture has been designed to support simulation of new topologies and protocols.

Future Work

- Complete simulations for other topologies (DCell, HyScale II and FiConn) and compare them.
- Simulate topologies for other parameters (other types of traffic, fault-tolerance and bisection-bandwidth)
- Extend ns-3 capabilities to support optical networks

References

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[3] Bilal, Kashif, Samee Ullah Khan, and Albert Y. Zomaya. "Green Data Center Networks: Challenges and Opportunities." Frontiers of Information Technology (FIT), 2013 11th International Conference on. IEEE, 2013

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Questions ?