Deconstructing Data Center Load Balancing with Network Traffic Profiles

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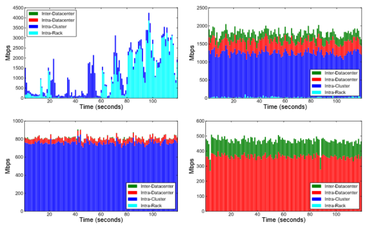
GOAL

Dynamically configurable load balancer.

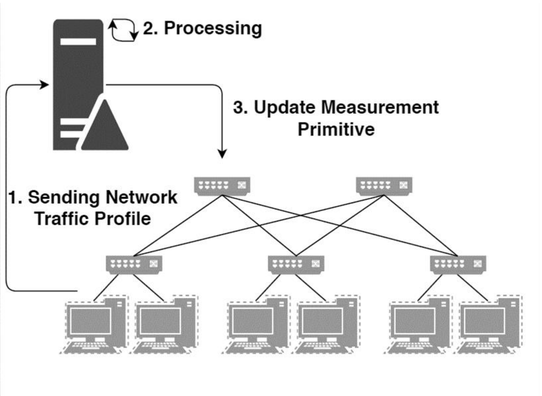


Link Utilization
Queue Occupancy
Heavy Hitter

Can adapt to traffic conditions

Use the correct measurement metric

VISION



- Programmable and extensive load balancer framework
- Each data center host regularly sends its ***network traffic profile to the centralized controller***
- Reconfigures dynamically based on traffic patterns, communication patterns and the topology.

MOTIVATION

Although all data center load balancing techniques try to **lower flow completion time (FCT)** and keep the **network links as utilized as possible** they leverage **different design choices**. This is because **data-centers are plagued with uncertainties**:

Traffic Patterns

Traffic can be highly dynamic in production level data centers.

Communication Patterns

There is high variability in the communication patterns in Data Centers.

Topology

Expansion + failures can cause asymmetries in the network topology.

Scheme	Granularity	Measurement Primitive	Designed For
ECMP	Flow	***None***	Generic topologies
Let It Flow	Flowlet	***None***	Asymmetric Topologies
Hedera / MicroTE	Flow	***Heavy Hitter***	Optimizing FCT for Elephant Flows
DRILL	Packet	***Queue Occupancy***	Best Performance when network load higher than 80%
Conga	Flowlet	***Link Utilization***	2-Tier Topologies
Hula	Flowlet	***Link Utilization***	Scalable Topologies

Takeaway: **No one measurement primitive is solely superior to the other.**

EXPERIMENTS

		Intra-Pod	Inter-Pod	
			Neighbors	Network-Wide
Web Search	Hula			
	Hula-OQ		✔	✔
	Hula-HH	✔		
Data Mining	Hula		✔	✔
	Hula-OQ			
	Hula-HH	✔		

Conducted experiments using the Hula NS2 codebase and varied the *measurement primitive*, *traffic* and *communication pattern*. The table summaries our findings from out experiments.

Scheme

HULA: An in-network load balancer that uses *link utilization* as measurement primitive
HULA-OQ: Used *queue length as measurement primitive*
HULA-HH: Used *heavy hitter as measurement primitive*

Traffic Patterns

Web Search: Characterized by a prevalence of short flows
Data Mining: More long flows than Web Search.

Communication Patterns

Intra-Pod: Most of the traffic resides in the same pod.
Inter-Pod: Majority of the traffic would be directed towards a **neighbor** or have to traverse the entire data center (**network-wide**)

Takeaway: **The choice of measurement primitive is predicated on the traffic patterns, communication patterns and network topology.**