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A Survey on Joint Static and Dynamic Traffic Scheduling in Data Center Networks

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Abstract - Network, a collection of two or more nodes that can share the data. In our modern world the rapidly increasing the internet users led to storing and updating the data very often. This scenario led into the data center (a collection of servers) where it maintain a huge database and thus need high capacities for interconnecting the thousands of servers in these data centers. A range of multilayer architectures have been employed. From this related work that the traffic in a data center is a combination of static and dynamic. To improve the throughput and minimize delay Load Balanced schedulers have been proposed and also incorporate an opportunistic scheduler that sends traffic on a feasible direct path.

Keyword: Dynamic traffic scheduling,Load balanced scheduled,Joint static

INTRODUCTION:

A data center is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and various security devices. Large data centers are industrial scale operations using as much electricity as a small town.

Data centers have their roots in the huge computer rooms of the early ages of the computing industry. Early computer systems, complex to operate and maintain, required a special environment in which to operate. Many cables were necessary to connect all the components, and methods to accommodate and organize these were devised such as standard racks to mount equipment, raised floors, and cable trays (installed overhead or under the elevated floor). A single mainframe required a great deal of power, and had to be cooled to avoid overheating. Security became important – computers were expensive, and was often used for military purposes. Basic design-guidelines for controlling access to the computer room were therefore devised.

During the boom of the microcomputer industry, and especially during the 1980s, users started to deploy computers everywhere, in many cases with little or no care about operating requirements. However, as information technology (IT) operations started to grow in complexity, organizations grew aware of the need to control IT resources. The advent of Unix from the early 1970s

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led to the subsequent proliferation of freely available Linux-compatible PC operating-systems during the 1990s. These were called "servers", as timesharing operating systems like Unix rely heavily on the client-server model to facilitate sharing unique resources between multiple users. The availability of inexpensive networking equipment, coupled with new standards for network structured cabling, made it possible to use a hierarchical design that put the servers in a specific room inside the company. The use of the term "data center", as applied to specially designed computer rooms, started to gain popular recognition about this time. The boom of data centers came during the dot-com bubble of 1997–2000. Companies needed fast Internet connectivity and non-stop operation to deploy systems and to establish a presence on the Internet. Installing such equipment was not viable for many smaller companies. Many companies started building very large facilities, called Internet data centers (IDCs), which provide commercial clients with a range of solutions for systems deployment and operation. New technologies and practices were designed to handle the scale and the operational requirements of such large-scale operations. These practices eventually migrated toward the private data centers, and were adopted largely because of their practical results. Data centers for cloud computing are called cloud data centers (CDCs). But nowadays, the division of these terms has almost disappeared and they are being integrated into a term "data center".

With an increase in the uptake of cloud computing, business and government organizations scrutinize data centers to a higher degree in areas such as security, availability, environmental impact and adherence to standards. Standards documents from accredited professional groups, such as the Telecommunications Industry Association, specify the requirements for data-center design. Well-known operational metrics for data-center availability can serve to evaluate the commercial impact of a disruption. Development continues in operational practice, and also in environmentally-friendly data-center design. Data centers typically cost a lot to build and to maintain companies rely on their information systems to run their operations. If a system becomes unavailable, company operations may be impaired or stopped completely. It is necessary to provide a reliable infrastructure for IT operations, in order to minimize any chance of disruption. Information security is also a concern, and for this reason a data center has to offer a secure environment which minimizes the chances of a security breach. A data center must therefore keep high standards for assuring the integrity and functionality of its hosted computer environment. This is accomplished through redundancy of mechanical cooling and power systems (including emergency backup power generators) serving the data center along with fiber optic cables.

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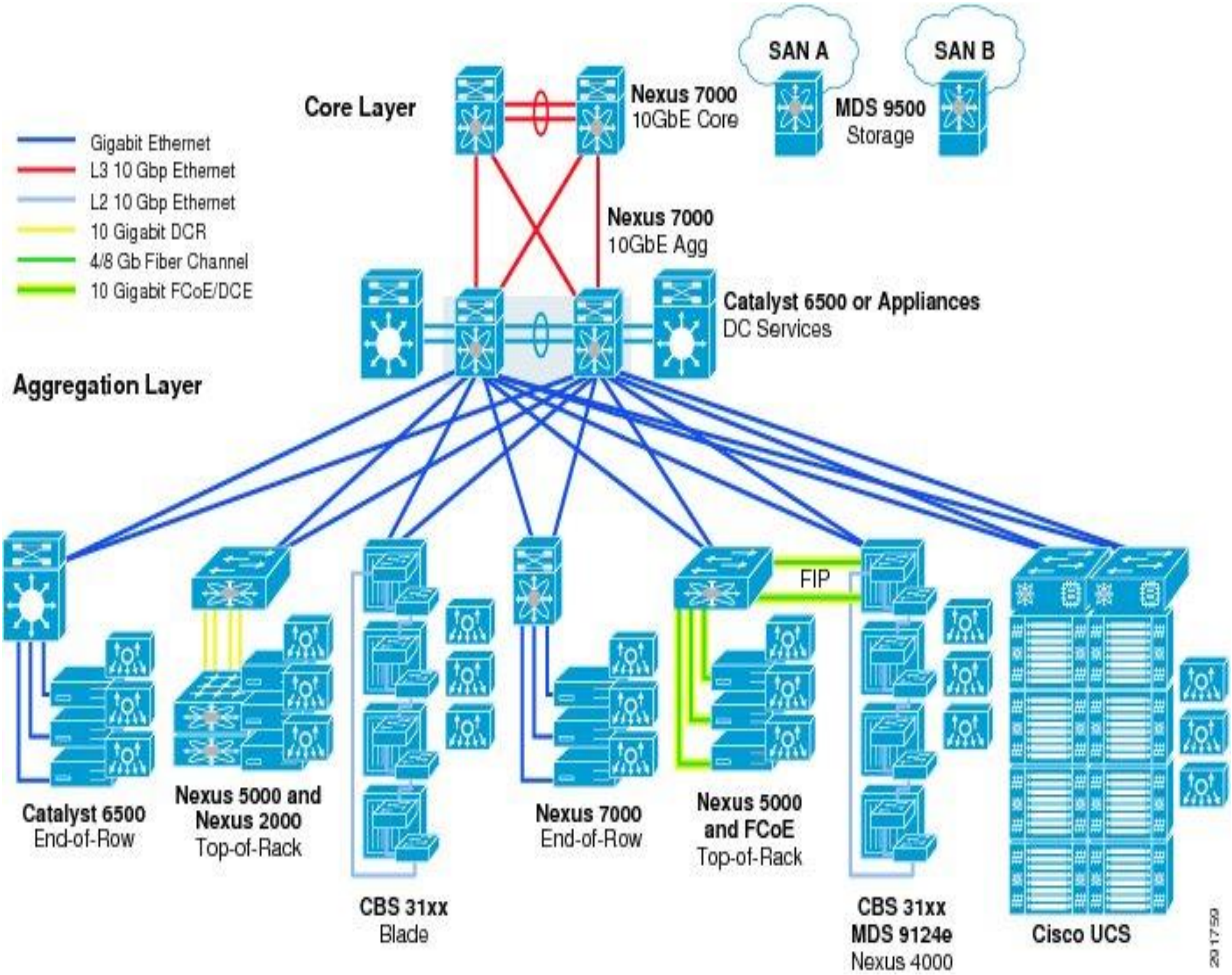

The Telecommunications Industry Association's TIA-942 Telecommunications Infrastructure Standard for Data Centers specifies the minimum requirements for telecommunications infrastructure of data centers and computer rooms including single tenant enterprise data centers and multi-tenant Internet hosting data centers. The topology proposed in this document is intended to be applicable to any size data center.

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Telcordia GR-3160, *NEBS Requirements for Telecommunications Data Center Equipment and Spaces*, provides guidelines for data center spaces within telecommunications networks, and environmental requirements for the equipment intended for installation in those spaces. These criteria were developed jointly by Telcordia and industry representatives. They may be applied to data center spaces housing data processing or Information Technology (IT) equipment. The equipment may be used to:

- Operate and manage a carrier's telecommunication network
- Provide data center based applications directly to the carrier's customers
- Provide hosted applications for a third party to provide services to their customers
- Provide a combination of these and similar data center applications

Effective data center operation requires a balanced investment in both the facility and the housed equipment. The first step is to establish a baseline facility environment suitable for equipment installation. Standardization and modularity can yield savings and efficiencies in the design and construction of telecommunications data centers.

LITERATURE WORK:

Data center is a pool of resources (computational, storage, network) interconnected using a communication network. Data Center Network (DCN) holds a pivotal role in a data center, as it interconnects all of the data center resources together. DCNs need to be scalable and efficient to connect tens or even hundreds of thousands of servers to handle the growing demands of Cloud computing.Today's data centers are constrained by the interconnection network.

HELIOS: (A HYBRID ELECTRICAL/OPTICAL SWITCH FOR MODULAR DATA CENTERS)

The basic building block of ever larger data centers has shifted from a rack to a modular container with hundreds or even thousands of servers. Delivering scalable bandwidth among such containers is a challenge. A number of recent efforts promise full bisection bandwidth between all servers, though with significant cost, complexity, and power consumption. We present Helios, a hybrid electrical/optical switch architecture that can deliver significant reductions in the number of switching elements, cabling, cost, and power consumption relative to recently proposed data center network architectures. We explore architectural trade offs and challenges associated with realizing these benefits through the evaluation of a fully functional Helios prototype.

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UNDERSTANDING DATA CENTER TRAFFIC CHARACTERISTICS:

As data centers become more and more central in Internet communications, both research and operations communities have begun to explore how to better design and manage them. In this paper, we present a preliminary empirical study of end-to-end traffic patterns in data center networks that can inform and help evaluate research and operational approaches. We analyze SNMP logs collected at 19 data centers to examine temporal and spatial variations in link loads and losses. We find that while links in the core are heavily utilized the ones closer to the edge observe a greater degree of loss. We then study packet traces collected at a small number of switches in one data center and find evidence of ON-OFF traffic behavior. Finally, we develop a framework that derives ON-OFF traffic parameters for data center traffic sources that best explain the SNMP data collected for the data center. We show that the framework can be used to evaluate data center traffic engineering approaches. We are also applying the framework to design network-level traffic generators for data centers.

LOAD BALANCED BIRKHOFF–VON NEUMANN SWITCHES, PART I: ONE-STAGE BUFFERING:

Motivated by the need for a simple and high performance switch architecture that scales up with the speed of fiber optics, we propose switch architecture with two-stage switching fabrics and one-stage buffering. The first stage performs load balancing, while the second stage is a Birkhoff–von Neumann input-buffered switch that performs switching for load balanced traffic. Such a switch is called the load balanced Birkhoff–von Neumann switch in this paper. The on-line complexity of the switch is $O(1)$. It is shown that under a mild technical condition on the input traffic, the load balanced Birkhoff–von Neumann switch achieves 100% throughput as an output-buffered switch for both unicast and multicast traffic with fan-out splitting. When input traffic is bursty, we show that load balancing is very effective in reducing delay, and the average delay of the load balanced Birkhoff–von Neumann switch is proven to converge to that of an output-buffered switch under heavy load. Also, by simulations, we demonstrate that load balancing is more effective than the conflict resolution algorithm, *i*-SLIP, in heavy load. When both the load balanced Birkhoff–von Neumann switch and the corresponding output-buffered switch are allocated with the same finite amount of buffer at each port, we also show that the packet loss probability in the load balanced Birkhoff–von Neumann switch is much smaller than that in an output-buffered switch, when the buffer is large.

DYNAMIC LOAD BALANCING WITHOUT PACKET REORDERING:

Dynamic load balancing is a popular recent technique that protects ISP networks from sudden congestion caused by load spikes or link failures. Dynamic load balancing protocols, however, require schemes for splitting traffic across multiple

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paths at a fine granularity. Current splitting schemes present a tussle between slicing granularity and packet reordering. Splitting traffic at the granularity of packets quickly and accurately assigns the desired traffic share to each path, but can reorder packets within a TCP flow, confusing TCP congestion control. Splitting traffic at the granularity of a flow avoids packet reordering but may overshoot the desired shares by up to 60% in dynamic environments, resulting in low end-to-end network goodput. Contrary to popular belief, we show that one can systematically split a single flow across multiple paths without causing packet reordering. We propose FLARE, a new traffic splitting algorithm that operates on bursts of packets, carefully chosen to avoid reordering. Using a combination of analysis and trace-driven simulations, we show that FLARE attains accuracy and responsiveness comparable to packet switching without reordering packets. FLARE is simple and can be implemented with a few KB of router state.

ON DIRECT ROUTING IN THE VALIANT LOAD BALANCING ARCHITECTURE:

It is very hard to design a network with performance guarantees, partly because it is hard to estimate the future traffic matrix. With no knowledge of the traffic matrix, one can use the valiant load-balancing (VLB) architecture which can support any traffic satisfying the node capacity constraints. To interconnect N nodes of capacity r, the VLB architecture requires a logical full mesh of link capacity c = 2r/N. Uniform load-balancing can guarantee throughput, but is not necessary if the traffic matrix is known, in which case the amount of load-balancing can be reduced. In this paper we study adaptive load-balancing in two cases: when only local traffic information is known to a node, and when the network traffic matrix is known. We give linear programming formulations to maximize directly routed traffic in both cases, so as to reduce the average hop count of packets. In the case when the traffic matrix is known, we show that direct routing is not always feasible with c = 2r/N, but c = 3r/N sufficient

Generalized Load-Balanced Scheduler (GLOBE)

Bridges the Birkhoff–von Neumann scheduler and the load-balanced scheduler.

GLOBE comprises two modules:

- ***Static Traffic Scheduling*** module that schedules the static traffic matrix while maximizing the throughput of the worst-case dynamic traffic.
\
- ***Distributed Cycle Canceling*** module that is implemented at the input nodes to opportunistically improve the throughput and delay performances of the schedule.

As part of GLOBE, we have developed the following:

- A simple algorithm for optimally allocating the traffic split ratios in generalized load-balanced switch to maximize the worst-case switch throughput
- A decentralized local information cycle canceling mechanism that can be used to

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further increase throughput

- A primal-dual approximation algorithm for optimal cycle canceling that uses a sequence of minimum mean cycles as the best cycles to cancel
- A simple and novel counter-based algorithm for practically implementing the

GLOBE-STS: STATIC TRAFFIC MODULE

Input: Static matrix $\mathbf{S}$
Output: Optimal split factors α_j.

1) Compute R_i and C_i for each node. (Equations 1,2)
2) Determine the optimal split ratio. (Equation 8).
3) Compute the flow between nodes i and j and the total traffic matrix $\mathbf{T}$ where

$$t_{ij} = s_{ij} + \alpha_j R_i + \alpha_i C_j \ .$$

4) Run the BV decomposition algorithm to determine the permutation matrices $\mathbf{P}_i$ and weights ϕ_i.
5) In each time slot pick the permutation matrix $\mathbf{P}_i$ with probability ϕ_i and use this matrix to set up the interconnects.

GLOBE DCC:

In GLOBE-STS, we assumed that each ingress node sends packets to intermediate ports according to fixed ratio indepen-dentofthe egress ports. Since the ingress node knows the egress nodes for all the packets that originate from it, it can take advantage of this fact to improve the performance of the interconnect network. Instead of routing obliviously to the final destination, it is possible to improve the throughput if the ingress node opportunistically sends packets directly to the

cycle canceling scheme.

The cycle canceling algorithm is of independent interest and can be used to improve the performance of any load-balanced switching architecture. We want to point out that packets can arrive out of sequence at the egress of a load-balanced switch.

egress node in one hop, thus reducing the traffic load in the second phase. This step called cycle canceling has to be done carefully respecting the capacities that are allocated by GLOBE-STS. This idea of cut-through routing in a symmetric load-balanced network was explored in. However, their approach does not extend to generalized load balancing.

1. GLOBE-2CC: Two-Arc Cycle Canceling

We first illustrate cycle canceling using a simple two-arc example. Consider input node . At the end of GLOBE-STS, the amount of Phase II traffic generated between ports and by traffic originating from node is the following.

- Of the traffic that has to be sent from node to node is sent to node in Phase I, and this in turn is sent to port from node in Phase II.

- Of the traffic from to , a traffic of is sent to node in Phase I, and thus is transferred from node to node in Phase II.

2. GLOBE-MCC: Maximum Cycle Canceling

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Consider a node . It minimizes Phase II traffic that it generates by first constructing a Phase II flow graph, and then solving an optimal fractionalcycle cover problem on this flow graph.

3. GLOBE-ICC: Implicit Two-Arc Cycle Canceling Module

We now show that GLOBE-2CC can be implemented without explicit estimation of the rates or checking the conditions given in the last section. All rates are estimated implicitly.

COMPARISON TABLE:

Schemes / parameters	STS	ICC	Globe STS	Globe ICC	Globe STS And Globe DCC
Delay	Very High	High	Medium	Very medium	Very low
Throughput	Very Low	Low	Average	Average	Good

CONCLUSION:

Numbers of internet users are rapidly growing leds to the storing and updating the data very often. This scenario led into the data center (a collection of servers) where it maintain a huge database and thus need high capacities for interconnecting the thousands of servers in these data centers. A range of multilayer architectures have been employed. To improve the throughput and minimize delay Load Balanced scheduler have been proposed and also incorporate an opportunistic scheduler that sends traffic on a Feasible direct path.The proposed outperforms the existing one.

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