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AN IMPROVED TECHNIQUE FOR OPTIMIZING ENERGY CONSUMPTION IN DATA CENTER NETWORKS

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Abstract

The Data Center Network (DCN) is the assembly of different kinds of resources providing storage, processing and network functionalities capable of transaction of billions of data worldwide every day. The power consumption of the DCN is exponentially increasing every year. The electricity consumed by the devices linked in the network which remain unused is wasted unreasonably and be avoided. Hence, this paper proposes a method of optimizing the power utilization in the DCN by reducing the waste of power consumption by unutilized network components. In this proposed method the topology of the network is made scalable. In addition, this method provides optimal path for packet transmission. The algorithm described in the paper decreases the number of active switches needed for communication. The inactive switches can be put into snooze mode. The packet loss is also prevented in great extent. The result shows the efficient operation of switches by consuming less electricity.

Keywords: DCN, Dynamic Power Allocation, Energy-Saving, Power Optimization, Topology, Traffic-Aware Routing.

1. Introduction

The Data Centers are the indispensable element of the infrastructure providing aid to the internet and thereby facilitate digital trade and electronic interaction segment. Data Center Network (DCN) contains the networking components, large volumes of servers, devices which need to cool the whole unit. The DCN structure consists of 3 Layers: Access, Aggregation and Core Level. Access layer approves of workgroup/user entry to the system. Aggregation layer deals with the rule-oriented interconnection of systems and manages the scope between the access and core layers. Core layer makes availability of swift transmission among the allocation switches within the premise. Aaron Rallo, founder and CEO of TSO Logic and who has spent more than 15 years in building and managing largescale transactional solutions for online retailers said Data Centers consume up to 3% of all global electricity production [5].

2. Related Work

Wang.L et al. [4] devised the framework that combines the topology design based on the traffic rate and the algorithm for routing decision to reduce the energy consumption. It is done by combining the Map Reduce and Energy Efficient Routing (EER) Algorithm. EER randomly assigns the required number of active switches. Multi-Path Transfer Control Protocol (MPTCP) [2] is used to route the data.

Ting Wang et al. [3] proposed a new powerful server oriented design named as SprintNet. In this approach, the Traffic Adaptive Routing (TAR) was implemented. TAR mainly helps in avoiding packet jamming and accomplishing traffic-flow optimization. Forwarding Unit is a peripheral oriented technique that separates the server from the set of connections and functions as the bridge. The average packet loss is decreased only if the number of forwarding switches is increased.

Guan.X et al. [1] proposed a Topology and Migration-Aware Energy Efficient Virtual Network Embedding (TMAE-VNE) Algorithm to curtail the power utilization considering the operation and origination. The resources and links are put to sleep mode if not needed. Robustness of the links is not provided.

The areas which are identified for improving the performance of the existing system further are:

1. The optimal path is not chosen for the traffic flow.
2. The architecture is not scalable.
3. The power consumption is not lowered.
4. The network utilization is completely reduced.

3. Modules

The number of switches and routers in the topology is not restricted. In fact, they can be added or removed dynamically. Also, the topology formed is modified periodically based on the count of network components. This provides the scalability of the network.

3.1 Route Table Computation

The route table is computed to determine the connectivity of each node. The topology constructed is considered to be a graph. The adjacency matrix corresponding to the topology is generated. A <*source, destination*> pair can have many routes. The proposed method finds out all possible routes between the source and the destination.

The route with minimum count of intermediate nodes is considered as the primary route. The primary route will be assigned highest priority for the data transmission. All the remaining routes are stored in the alternate paths table. Since the primary route is the shortest of all routes, the time for the data transmission is drastically reduced. The routing table is periodically updated as and when the topology is changed dynamically.

The graph G containing the topology and the number of routers 'n' is given as input for *Squat-Track Algorithm*. The Primary Path is denoted as Vp. The unused routers are put in snooze state.

3.2 Topology Scrutinizer

The fail-over mechanism, which should be mandatory component of any mission critical system for supporting a back up operational mode to activate the secondary system components as and when the failure of functions of primary system components, plays a vital role in the proposed system.

The monitor scrutinises the status of every link between the nodes. In case the link between any nodes is broken, it immediately diverts the incoming traffic for the intended <*source*, *destination*> pair through the alternate paths which is unaffected by broken link.

If the broken link is restored, the route with the minimum count of intermediate nodes is re-elected as the primary route. The traffic is again made to pass through the primary route. In case, if many links are broken due to node failures, the topology is freshly constructed eliminating those collapsed nodes. In such scenarios, the route table is re-computed.

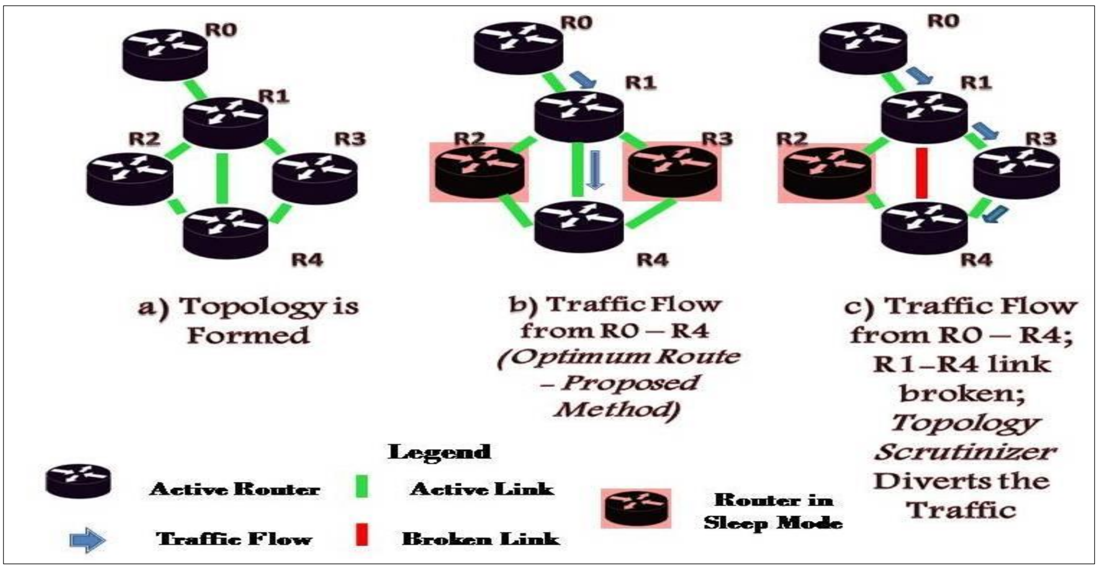

Figure 1 Squat - Track Method and Topology Scrutinizer.

The Topology is formed with certain number of routers as depicted in Fig 1.a. For example, let the <*source*, *destination*> be <*R0, R4*>. The proposed Squat-Track Algorithm chooses the optimum path for transmission. (Fig.

1.b) The link *(R1 - R4)* is broken; The *Topology Scrutinizer* diverts the traffic through an alternate path for *<R0, R4>*. (Fig 1.c).

Algorithm

Squat-Track (G,n)

Begin

V: Array of paths connecting <source, destination>

Select Vp with Min. Nodes as Primary Route

Assign $V - Vp$ as Alternate Routes

Call *TopologyScrutinizer (G, V)*

End

TopologyScrutinizer (G, V)

Begin

Vp: Primary Route

Fr: Failed Router

If ($link\ failure\ ==\ true$) {

Select a route from ($V - Vp$) routes eliminating Broken Link

}

If ($router\ failure\ ==\ true$) {

Eliminate the Fr

Call *Squat-Track (G, n-1)*

}

If ($link\ restore\ == true$) {

Reassign old Vp as Primary Route

}

If ($router\ restore\ ==\ true$) {

Establish the connection with Other Routers

Call *Squat-Track (G, n)*

}

End

EnergyCalc (n)

Begin

$\text{timestamp}_{\text{last transmission(i)}}$: Timestamp of last data transmission via ith node

$$\text{newVal(Energy Consumption}_{\text{Active}}\text{(i))} = \text{oldVal(Energy Consumption}_{\text{Active}}\text{(i))} + \text{timestamp}_{\text{current packet flow}} * (\text{Req\_EU(i)})$$

$\text{Energy Consumption}_{\text{idle}}(\text{i}) =$

$(\text{Current Time} - \text{Timestamp}_{\text{last transmission(i)}}) *$ Idle_EU(i)

for i = 1 to n {

Total Energy : Total Energy + $\text{Energy Consumption}_{\text{Active}}(\text{i}) + \text{Energy Consumption}_{\text{Idle}}(\text{i})$

}

End

4. Discussion

The topology is randomly generated with the count of routers and switches at each level. The traffic is generated for the randomly chosen <source, destination> pairs. The routers that are not involved in the transmission are put into snooze mode. The fail-over mechanism provided by the *Topology Scrutinizer* module is also tested.

The energy consumption is measured by *EnergyCalc* Algorithm. In the *EnergyCalc* Method, Req_EU(i) is the energy required by the i th node for transmitting a given packet. Idle_EU(i) is the energy consumption of i th node at sleep state/idle state.

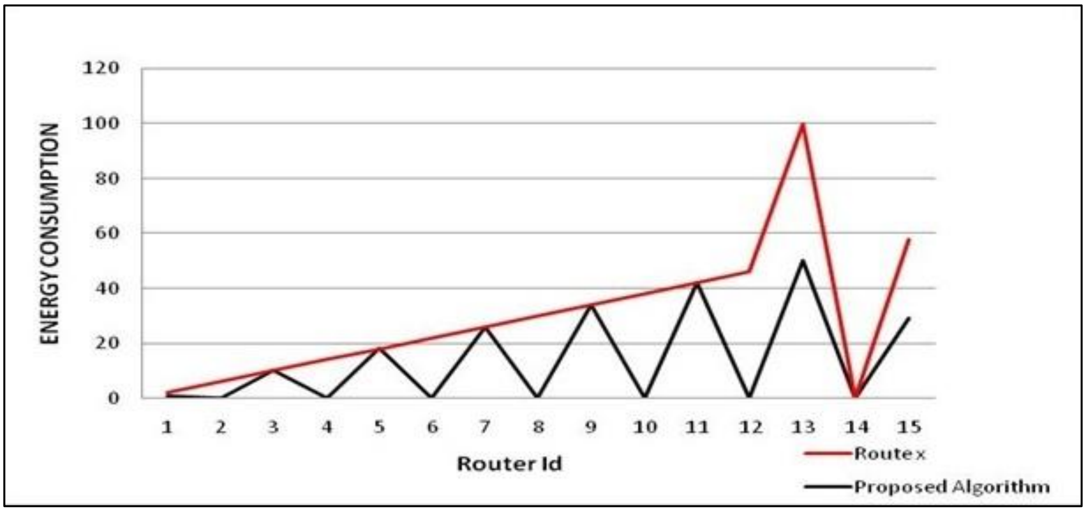

Figure 2: Comparison of Energy Consumed By Each Router during Data Transmission.

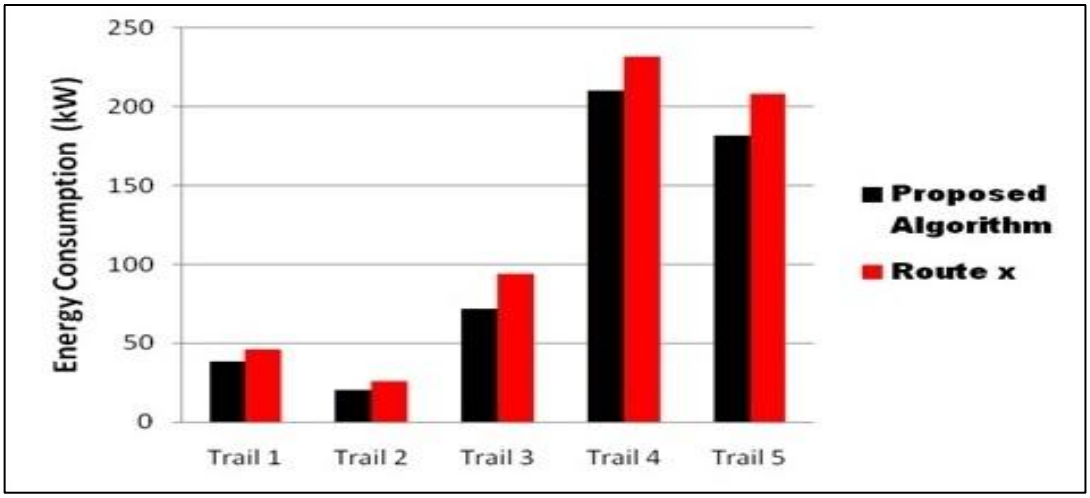

Figure 3: Comparison of Total Energy Consumption during Data Transmission.

Figure.2 represents the comparison of energy consumption of each router. Figure.3 represents the total energy consumption of routers involved in various trails of data transmission. The simulation results clearly show that the proposed method consumes less electricity.

5. Conclusion

Thus, the methodology presented in this paper forms the topology dynamically. Modification of the structure of the network is recurrently reflected in the routing table. The shortest path is elected for the data transmission connecting less number of switches. The simulation results depicted the increased reduction of energy consumption of the Data Center Network. The devised model also suggests the solution for selecting an alternate route in the event of failure of node or link. The load balancing technique can be imposed in order to make the usage of bandwidth more efficiently.

6. References

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