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Multi-Level Routing Mechanism for Energy Sensitive and Controllable Software Defined Networks

E. Sivarajan[1], *Dr. V. Jeyalakshmi*[2]
[1]*Research Scholar, Department of CSE, Anna University, Chennai, India.*
[2]*Professor, Department of ECE, Anna University, Chennai, India.*
Email ID: *sivarajan19051986 @gmail.com*[1], *jpjeya@gmail.com*[2]

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Abstract
The objective of Software Defined Networking architectures is to prevent the excessive usage of energy required for routing and enabling devices across the network. The predominant measure of energy optimization technique is facilitated by proper planning of the routing mechanisms, where the algorithms determine the approach involved in sharing the messages around the devices at different locations. The proposed research article summarizes the techniques included in planning and mapping strategies for a green policy adhering to critical approaches and establishment of Data Centers. There are two significant planes that define, monitor and regulate the traffic of messages between the various devices of the network. The proposed strategy follows multiple-level planning and addresses the mapping problem which is persistent in existing approaches. The controlling plane is responsible for the effective placement of data center's and switches for energy-saving traffic routing. The controllers are placed in predefined locations that are marked to be optimal locations by the mapping algorithm. The proposed algorithm follows the NP-hardness algorithm to define the various routes between different devices such as controllers and switches. The defined paths and immediate routes taken in situations of peak hours and other failures are clearly identified by the proposed algorithm well in advance for effective energy conservation. Effective mapping is also ensured by proper reallocation of routes which are defined as cost effective and fail-proof route to ensure completion of traffic. The defined algorithm enabled the Software Defined Networks to conserve energy up to 72% when compared to existing state of art techniques.

1. Introduction

Separation of the control and data planes of the Software-Defined Networking (SDN) paradigm. The conventional routing approaches demand the intervention of hardware components where the routing protocols are defined. Since the control plane in SDN eases the operation through a software interface, the process of routing is simplified and enables the administrators to automate multiple processes unlike the traditional approaches. It enables flexible and efficient network management and traffic management. Advanced communication technologies such as Networks Function Virtualization (NFV) are enabling data centre's (DCs) to deploy more innovative programmable power management systems. Controllers and servers housed in DCs monitor and execute all operations and control traffic within such high-speed networks. Multiple network domains consist of WAN-DCs (Wide Area Networks) located in different domains operated by multiple operators and service providers. Each DC has many network devices. B. SDN switches in different locations. As a result, excessive DC power consumption becomes a problem for SDN as the network's underlying network resources and connections expand. Excessive traffic also results in inefficient use of a large number of nodes (switches and routers) and high energy running costs. In this context, the SDN control plane and management plane use the routing protocols and signaling constructs available in the infrastructure to enforce and maximize network utilization in a green policy architecture. The aim is to develop appropriate techniques to reduce and conserve grid energy without sacrificing performance. On the other hand, traditional routing algorithms struggle to identify optimal flow paths and reduce network power consumption. While they provide static routing options for flows, they lack the flexibility to change flow routes to meet quality of service (QoS) requirements and balance link utilization based on changing network conditions. Under these circumstances, current research relies on grid energy strategies and employs efficient flow management techniques to achieve further energy-saving his solutions. A performance-oriented traffic design should use fewer links without increasing link congestion or delaying flows. Also, routing paths must be manipulated to provide multiple paths while maintaining network performance and reliability. Performance-oriented traffic design should use fewer links, increasing link congestion and flow latency. Also, routing paths must be manipulated to provide multiple paths while maintaining network performance and reliability. Additionally, limiting the number of active components while considering control and data plane traffic is a simple and efficient technique for consolidating data network usage and minimizing power consumption. For example, in over provisioned networks, power-aware routing approaches consolidate traffic across many links and devices. However, some approaches use energy-aware routing techniques that allow backbone networks to use different traffic aggregation algorithms to reduce link load. In addition, some energy-related network research relies on using efficient routing algorithms for link monitoring and path assignment. Other research attempts to reduce the number of hops between switches and controllers by looking only at the data plane over SDN. Also, data plane connections must be routed through the network controller. Regardless of the relevance of resource allocation placement strategies to network efficiency, the impact of energy cannot be overlooked. We therefore believe that there is still a potential need to quantify energy efficiency, resource utilization, and network load balancing to support power-aware routing strategies. SDN-based distributed control networks, multi-controller architectures, and optimal network performance must consider key factors to achieve high efficiency and energy savings. Dynamic controller changes in allocated path quality, control load, and resource management affect network load distribution among controllers in rapidly increasing network densities. However, it introduces some problems. This can happen when the mapping process only evaluates the number of hops and does not consider the propagation delay of the connection. For example, propagation delay is an important factor in association calculations in large networks. On the one hand, sending streams of traffic over shorter paths reduces latency and improves network utilization. This reduces energy consumption. Therefore, the optimal placement and number of controllers in the core network will help to optimally map connections and paths between controllers and switches, minimize the number of required network devices, and reduce power consumption. In this research, an energy sensitive routing technique is developed to implement optimal traffic routing mechanisms between network entities. This problem is addressed by a multi-level policy-based mapping approach that carefully determines the optimal mapping between controllers and switches to optimize network power savings. A two-phase algorithm is used for this. In the first phase, the assignment and mapping problem can be modelled as a Novel Controller Placement Problem (CPP). The maximum power consumption associated with directional links is then included in the second phase. Therefore, through research, this research work finds trade-offs between latency, cost, and resilience. An energy-aware multi-destination routing mechanism was developed using a multi-level plane arrangement. This strategy uses realistic dynamic traffic routing schemes and appropriate resource allocation to conserve network power and reduce overall power consumption. The model leverages capacity and network topology awareness and network flow traffic management techniques to meet control path and controller load balancing constraints while reducing overall power consumption and overhead communication costs. The number of active links is reduced by performing an optimal mapping between controller locations and network entity mechanisms in a distributed SDN with multiple controllers using the proposed control plane placement algorithm. reduce and save power. gain. This white paper aims to evaluate various predictors that influence allocation, optimal allocation, and dynamic resource allocation in SDN, leading to energy savings. As a result, the algorithm's performance was evaluated in terms of many factors, including propagation delay, controller capacity, robustness, and optimal amount of reference allocation. Therefore, in this study, we investigated energy-aware approaches across multiple network topologies to evaluate energy consumption strategies in SDN-based networks for efficient use of resources and green networks. [1-3]

2. Related Work

The idea of energy-efficient green networking has become an important topic for industry and science in recent years for both economic and environmental reasons. A complementary main direction in network power saving methods focuses on network-wide traffic engineering/analysis and routing optimization models with various constraints to reduce power consumption. Additionally, limiting the number of active components and traffic requirements impacts the power consumption of network hardware. Therefore, this study formulated a performance-oriented approach to SDN networks that combines dynamic routing and control plane configuration. This technique reduces the number of active nodes and links required to dynamically handle changing traffic patterns within the network. Rather than restricting the functionality of energy-aware solutions to low-load conditions, this study focuses on energy-aware solutions that minimize energy consumption while avoiding degraded high-priority traffic performance in the network. Another study presented an energy efficient routing traffic management algorithm. The algorithm takes into account the different throughput requirements of flows in different network topologies with link capacities defined to minimize the number of hops. Although of low complexity, the proposed routing technique focuses on power saving for SDN integer linear problems (ILPs) by examining only traffic and demonstrating that data plane connections cannot be sent between controllers. Increase. I'm guessing. Additionally, when shortest routes are used, links and nodes are weighted based on their state, as shown in previous work.To satisfy the distribution constraint at a lower cost than single-path routes, the proposed Dijkstra-based randomized routing (RDBR) applied centralized routing control by random node placement. After reformulating the problem as an unconstrained one, sub gradient descent was used to determine the Lagrangian multipliers. Network traffic metrics can lead to cost savings, but many other performance indicators are taken into consideration. For example, if a link is congested and QoS cannot be maintained, new local routing change procedures can be proposed that adjust network routers and links before and after the congested path instead of the full path. On the other hand, the routing configuration is more constrained, so the optimization challenge is more computationally intensive. Both flow-based routing and shortest-path routing can use one path per flow or multiple paths per destination. In such cases, shortest-path routing allows network administrators to adjust the weights of only a few links, one for each link. This can be easily changed using modern management techniques. In addition, traffic flow time is reduced under controller load while maintaining network stability and meeting QoS criteria. Multi-controllers in the SDN control plane can achieve better power savings by distributing switches among controllers in the most power efficient manner while also considering load balancing between controllers. SDN helps reduce power consumption by providing realistic routing algorithms and proper mapping based on optimal controller placement and mapping sites. Therefore, several heuristics based on variable measurements and near-optimal assertions have been proposed to address such multiple-metric and computation-time problems. In this research he developed his ILP. This is a performance-focused approach that optimizes the number of active links shared between data and control plane traffic when the controller is optimally placed in the network he topology. This model simply accounts for link loading and control path delays. Despite these fluctuations, traffic is often defined by a time profile, allowing network operators to plan ahead. Therefore, the network administrator should optimize network configuration based on traffic forecasts or real-time traffic measurements. Additionally, it is important to consider that SDN network switches, links, and CPU cores consume a lot of energy. Therefore, this model outlined power efficiency techniques and key issues by spreading the controller load across a large number of CPU cores while reducing the operating frequency. However, the algorithms were complex, and while more sophisticated processes could be implemented, he was inflexible to handle contingencies in SDN without considering traffic. Note that SDN-based EAR networks often rely on specific structures to collect data, distribute configuration instructions, and provide robust controllers. The following figure illustrates the model architecture of conventional approaches for routing and operations in SDN.

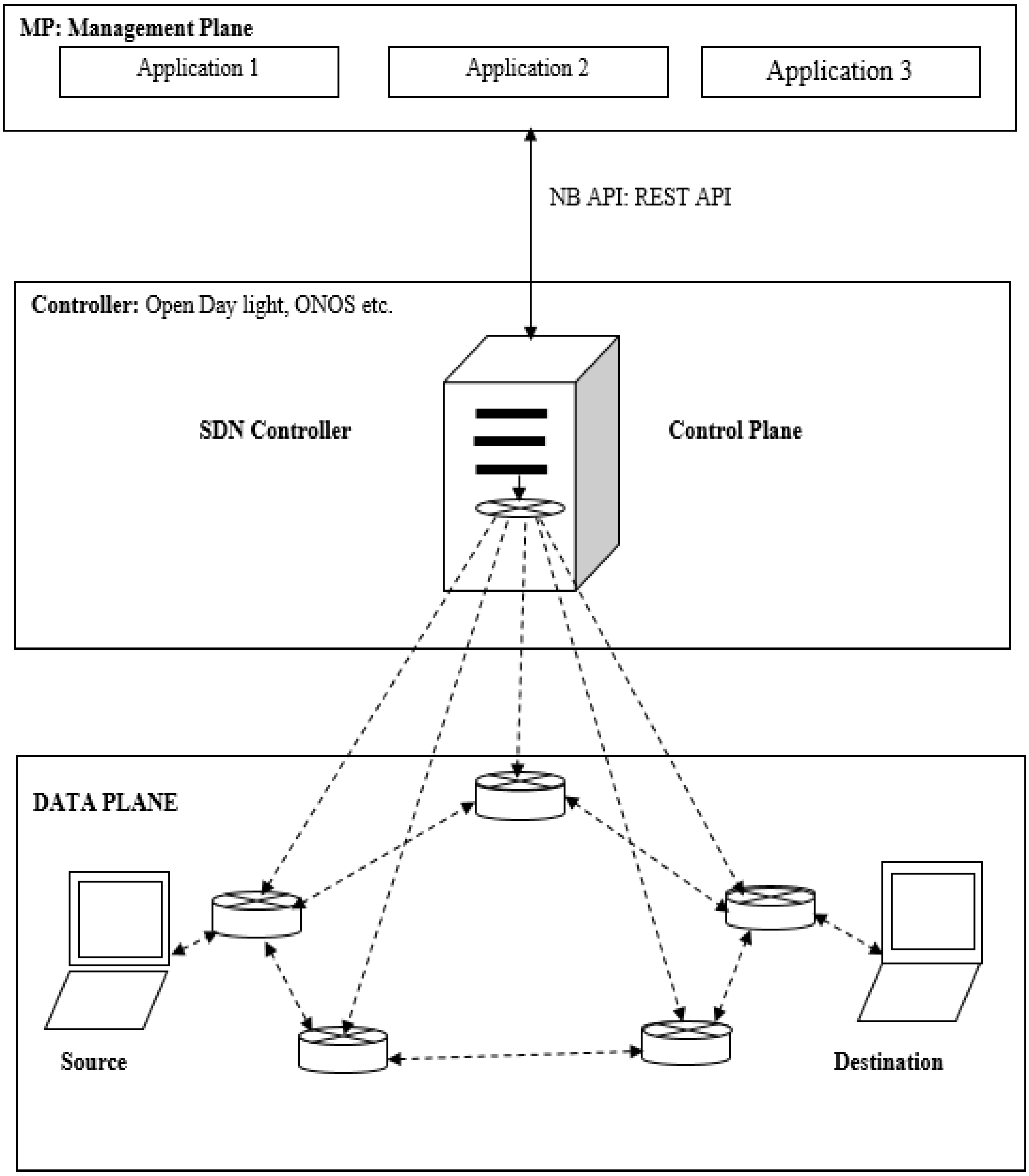

Figure 1 **Architecture of SDN Model**

Dynamically managed to meet service requirements and efficiently use network resources. Integrating virtualization and SDN is a viable approach to effectively manage available resources by leveraging centralized control to achieve scalable network operations. Addressing such issues requires making some important and difficult trade-offs between different goals. It's also important to put them in low power mode to reduce network power consumption. Considering an integrated SDN and NFV delivery framework, several multipurpose algorithms have recently been proposed to address energy-efficient multi-domain network services. The proposed heuristic maximizes power consumption and load balancing in multi-domain networks, considering only resource allocation. Similarly, research focuses on reducing power in hybrid SDN/NFV by applying a modified Dijkstra-based path selection mechanism to power down nodes. Similarly, the study enabled energy-efficient, traffic-aware deployments to reduce operational and network traffic costs. Virtual network functions on physical nodes, which must control all network flow service chains and keep network traffic costs low, must handle heterogeneous physical nodes and workloads.However, with increasing network activity and continued growth, distributed networks face significant challenges in load balancing and power saving. Most complicating feature of multidomain network deployments is the lack of global awareness of all domains. When routing such traffic over a set of links, Certain connections are overloaded and affect the energy consumption of the network infrastructure. Such sudden changes in traffic due to unexpected activity can lead to network failures, reduced capacity, and data loss. Reduce energy-hungry resources in the core, such as: B. Large IP routers can reduce the energy efficiency of the entire network. For example, a master controller in the management and orchestration layers that directly connects to the Internet and lower-layer traffic provides a more energy efficient solution. Using methods to increase the reliability of information collection and the robustness of QoS can provide many power-related benefits while saving power. By implementing network redundancy policies, the core network can manage service resources and scalability. A subset implementation of the conceptual model provides a reliable network with multiple redundant links and excessive bandwidth congestion. However, these redundancies reduce power efficiency when all network devices are powered on at maximum capacity. Redundancy makes network performance more reliable, but it also greatly increases network capacity because there are fewer active elements. They are contradictory because reducing the number of active nodes in a low-cost network increases the total physical link and node traffic and incurs a network latency penalty. Link aggregation, on the other hand, is important because you can easily improve link functionality by implementing new controller rules. However, the controller can improve the overall performance profile of the network by specifying which devices are put into low power mode based on flow QoS requirements. However, the controller can improve the overall community power profile by deciding which devices to put into low power mode based primarily on the QoS demands of the information flow. Otherwise, for website visitors, the Community Gadget adheres to the drift table and delivers incoming packets according to the Data Controller's existing regulations. Visitors to network sites below the information and operations layers also need to be organized and rerouted through backhaul communities and cores that are often constrained by bandwidth, latency, capacity, resources, and cost performance. Figure 1 shows Architecture of SDN Model [4-8]

3. Proposed Multi-Level Routing Mechanism

The proposed routing algorithms aim to find optimal routing and resource sharing in the core network while saving energy. The developed energy-aware solution is applied to the grid energy feature cost multi-level placement problem (MLP). Energy-sensitive routing problems are known to be NP-hard, so it is difficult to obtain fast solutions in such large-scale topological situations. Therefore, a comprehensive heuristic was developed to provide a near-optimal solution to his SDN power consumption problem mentioned earlier. Such network heuristics enable competing decision makers to balance goals and solution times in order to deliver superior solutions on time. Therefore, there is no single goal that helps decision makers find an approximate set of non-dominant solutions from this set. Also, by defining some constraints or weighted objective functions, to make decisions before invoking optimization. On the contrary, the provision of a viable solution is evaluated by all targets, after which a decision is made. Moreover, given a set of solutions for a particular combination of goals, we only need a function that translates components of the search space into performance at a particular goal. Therefore, CPP can be efficiently processed using heuristics from the field of multi-objective combinatorial optimization. Dynamic controller resources are provisioned using distributed local network mechanisms to limit the number of active nodes and links while meeting QoS criteria and reducing power consumption. Finding placement performance is therefore evaluated as a reasonable compromise between various competing objective measures and conditions essential for efficient operation. B. Location, number of switch controller latencies, and load balancing. Decision analysis topics are a subset of multi-criteria decision-making, and choosing among them is the main focus of multi-criteria optimization and multi-criteria decision-making. On the other hand, lowering routing costs requires more servers and increases deployment costs. To ensure low latency and high availability of server locations, computing acceleration approaches should be limited to power consumption. This will improve network quality. A power-conscious approach focuses on using multiple/shortest routes per request, keeping the number of controllers, number of active connections, and total power consumption of active connections as low as possible. increase. minimal cost. This work only refers to the power consumption generated by the controller nodes and links. Controllers (servers/routers) located in service regions have different resource capacities. Memory, compute, and storage resource requirements that consume a lot of server power. Additionally, the optimal number of switches handled by the controller should represent the load on the controller. Optimal allocation can therefore effectively distribute servers over a set of optimal locations with a given set of requirements and connection capacities to achieve load balancing and reduce overall power consumption. Figure 1 shows the flow path from source to destination using the most commonly used paths. An SDN network typically consists of three SDN domains. Each domain is managed by a centralized domain controller that controls all underlying network switches and forwarding devices. We assume that the routing path follows the least flow route with more active nodes based on an energy efficient approach. In general, flow cost is the percentage of flows that cannot exceed the bandwidth of a connection. If the flow is routed through a network segment, the link capacity A is either a constant (possibly given per link) or a cost function during network construction. Additionally, control messages are split using the same connection as traffic, with no additional edges. In this way, appropriate routing decisions can be made based on sufficient information gathering based on optimal control locations and resource sharing. In this way, the energy-aware routing output can be evaluated. Reducing subsequent hops reduces the cost per group, improves group balance, and reduces latency for short connections. In terms of network traffic and routing policies, networks should be optimally allocated to maximize power consumption while meeting the traffic requirements of all network interfaces. However, the location and number of controllers in the network affect energy savings. A maximum number of controllers can create compound links connecting two network entities. Since links contain a large number of switches, the total power used to carry traffic along the route increases by increasing the number of nodes connected to the available controllers. In addition, switch power consumption is often determined by the average processing time of traffic handled by the queue buffer switch. The calculation of the total power consumption of the network takes into account the connection load and the capacities of physical and virtual components. Additionally, it optimally redirects traffic and gets rid of idle capital by putting it into a low power state achieves significant energy savings. The result is network load balancing and reliable status. The modified version is also easier to implement by changing the classical K-equals shortest path selection method in root sub-problem selection. The path length is calculated based on the number of hops between the pair of source and edge switches. Addressing energy-aware architecture and routing challenges within the constraints imposed by the implementation framework is a key concern. This methodology searches for optimal routes between network components while limiting the number of active connections to reduce power consumption. First, the algorithm defines and evaluates all network connections and associations based on

Algorithm 1. Therefore, shortest-path routes and link weights can be scaled proportionally to physical distance to accommodate requirements, and vice versa, to perform link capacity checks. Similarly, power solutions aggregate traffic across limited network connections. For this purpose, an initial set of routes is generated in the first step. Figure 2 shows SDN Architecture [9-11]

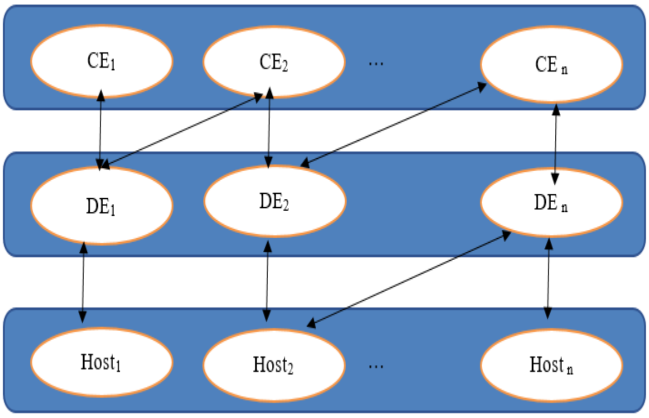

Figure 2 SDN Architecture

4. Algorithm

1. Define the positions of controller planes along with data planes [12-15]
2. Define the traffic matrices according to the positional parameters of controller and data planes as defined in the architecture
3. For each node in the network,
   - Initialize the cost
   - Define the routes between all composed nodes
   - Identify the least preferred nodes
   - Finalize the list of possible routes

The dynamic variables are estimated using the following equation, where α represents the time and rate of learning. S indicates the distance between the nodes and an indicates the action which is supposed to be carried out.

$$\begin{cases} Q_{k+1} s_t, \alpha_t = Q_k s_t, \alpha_t + \alpha_k \cdot \delta_k , \\ \delta_k = \gamma_{t+1} + \gamma \cdot \max Q_k s_{t+1} , a' - Q_k s_t, \alpha_t \left(a' \in A \right) \end{cases}$$

4. For each node,
   - Identify the shortest path to every other node
   - Update the most preferred route, in addition, t means time and q is defined as a special dynamic variable in mathematics.
   - Define the cost for every selected path using the following equation
   - Update the controller with the total cost required for transferring the packets

$$\begin{cases} \sum_k a_k^2 < +\infty \ , \quad \sum_k \alpha_k = +\infty , \\ \lim_{k \to \infty} Q_k = Q^* . \end{cases}$$

5. For all routes
   - Define the maximum capacity of every controller
   - Identify the maximum utilization for transferring packets through the selected routes
   - Identify the second most preferred route
   - Update link condition
   - Update Link status
6. Express the final list of routes, number of hops required from source to destination and total cost required Figure 3 shows Flow Chart
7. On the other hand, the routing configuration is more constrained, so the optimization challenge is more computationally intensive. [16-20]
8. Both flow-based routing and shortest-path routing can use one path per flow or multiple paths per destination.
9. In such cases, shortest-path routing allows network administrators to adjust the weights of only a few links, one for each link.

This can be easily changed using modern management techniques. In addition, traffic flow time is reduced under controller load while maintaining network stability and meeting QoS criteria. Multi-controllers in the SDN control plane can achieve better power savings by distributing switches among controllers in the most power efficient manner while also considering load balancing between controllers. SDN helps reduce power consumption by providing realistic routing algorithms and proper mapping based on optimal controller placement and mapping sites. Therefore, several heuristics based on variable measurements and near-optimal assertions have been proposed

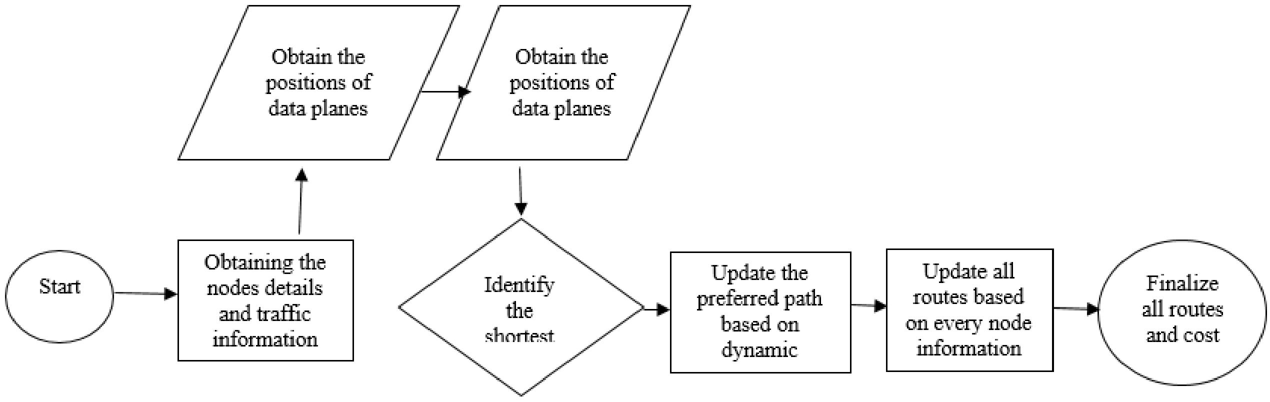

Figure 3 Flow Chart

5. Results and Discussions

In our simulations, we considered network traffic and power generation according to a predefined optimal site structure and the number of controllers achieved by the previous algorithm. We randomly generate a topology that resembles a real network chosen from zoo topologies. These networks have been used extensively in the literature to evaluate alternative controller placement techniques. To simplify the simulation, we focus on a number of large networks, choose three topologies of different sizes and configurations, compute all possible routes, and evaluate their power consumption. We found that the network tested had different power levels that applied different control loads from the switch to the controller, generated at random intervals ranging from 20 Mbps to 100 Mbps. The controller is set to 7800 k packets/sec as obtained from the throughput setting. Each OpenFlow switch connected to the server has a capacity of 1 Gbit/s for all connections. The performance of this technique is compared to two other EAR techniques that use the shortest path routing algorithm. a) Method 1, the original Distance-Based Energy-Aware Routing Algorithm (DBEAR) shortest-path algorithm with the standard Dijkstra algorithm, and b) Method 2 with constraint-based distance-based His EAR (C_DBEAR) capacity Limited. Traditional shortest-path selection methods are often used to compute the hop length and number of hops between source and destination edge switch pairs. However, this conventional method does not consider changes in link state information when calculating the route of data flow between source and destination nodes based on distance. A route is constructed node by node using an unconstrained algorithm, starting at the source node. Each step adds a node to the root. This is the next node on the unconstrained shortest path from source to destination, given the starting node of a partially constructed path. On the other hand, method 2 chooses the next active node with the shortest distance due to the shortest path constraint. Figure 3 shows Traffic Requirements and Energy Conservation According to Figure 2, the traffic requirements and the energy conservation rate is explicitly evident that the proposed technique is superior to the other approaches which are simple and polynomial complex. But there is no guarantee that the routes created can provide the best solution. The shortest route between the current node and the worst performing controller performance. The cost is returned along with the network link rate allocation. Performance comparison on the average cost of energy consumption for three categories of networks, from small networks (25 nodes and 87 links), medium networks (54 nodes and 181 links) to large networks (100 nodes and 460 links). is executed. Executed) Figure 4 Energy Conservation Based On Number of Controllers in The Network The total energy saving cost of the network is therefore the total performance cost of the algorithm with minimum routing selection. The number of hops as depicted in Figure 4 illustrates that the larger the network architecture, the number of hops is considerable reduced and hence the energy conservation mechanism in the proposed model works efficiently as deduced. The routing selection process prioritizes the selection of active nodes for controller locations. On the other hand, increasing network size increases traffic requirements and overall routing costs. [21-23]

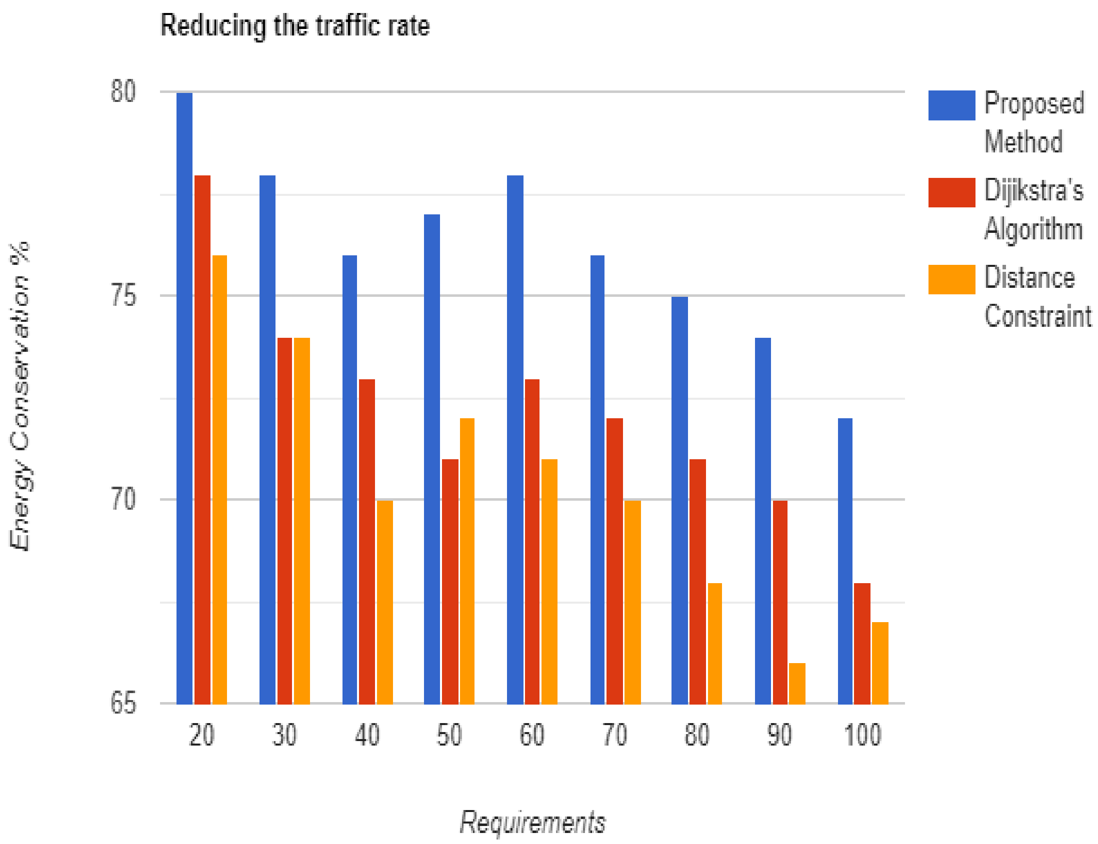

Figure 3 **Traffic Requirements and Energy Conservation**

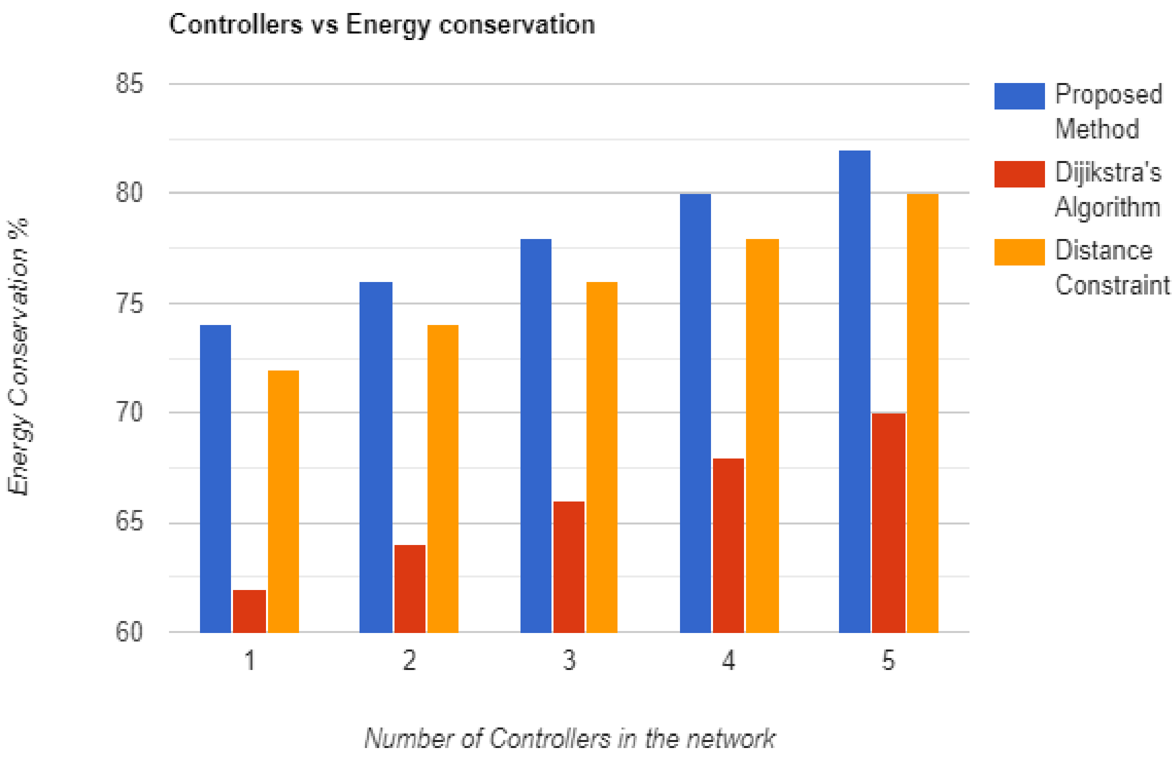

Figure 4 **Energy Conservation Based On Number of Controllers in The Network**

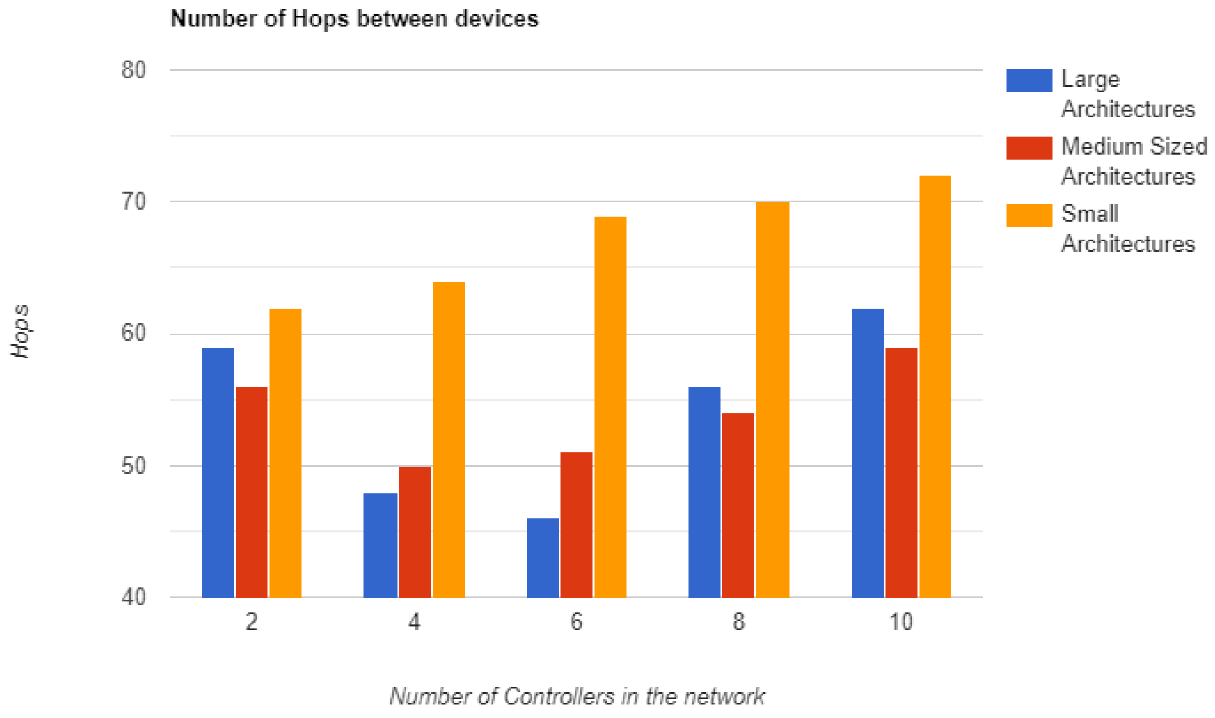

Figure 5 Number of Hops Required

Therefore, Figure 2 shows that for a 25-node network with a traffic demand of 100, the routing cost is approximately 500. As the number of requests grows, more servers (more services and traffic) are deployed in a multi-domain network. However, these servers consume more power, as they require more resources such as CPU and memory to instantiate the services provided and NFs to ensure reliable operation. make. However, with these numbers, the minimum routing cost of the proposed algorithm is about 20% compared to other algorithms. Nevertheless, we continued to monitor the improved delay of the power control path and examined the trade-off between delay and power consumption. [24-30]

Conclusion

This research article discusses power awareness in distributed network architectures for efficient routing and power savings in SDN. In distributed systems, controller rules apply. Power is conserved through placement and load balancing between links. However, it is difficult to reduce route length when network elements work together in his SDN framework. Therefore, like network elements must be interoperable. Therefore, a distributed control plane controller is provided in this work to maximize power savings opportunities in SDN. Performance aware algorithms are therefore aimed at optimizing power consumption and load balancing levels. Several metrics were considered in this model, including distributed network topology, rerouting of traffic flows, number of active links/devices, and number of hops. A high-quality network management system is used to demonstrate power savings in adjusting various traffic loads and determining number limits. An active device that provides power savings while maintaining proper routing functionality. The proposed energy-aware multiple mapping strategy routing technique combines resilience and resource management to optimize network energy savings throughout the evaluation process. Displays simulation results for the model. The proposed method outperforms other algorithms for various network sizes.

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