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Distributed Efficient Joint Resource Allocation using Conjugate Gradient Method for Software-Defined Networking

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***Abstract*—** Network operators run various applications on the control platform to perform different management tasks, like routing, monitoring, load balancing and firewall. These applications have complex interactions with each other, making it difficult to deploy and reason about their behaviours. To solve these kinds of problem, this paper presents a Distributed efficient joint resource allocation using conjugate gradient method (DEJRA-CG) is to accurately calculate the average energy consumption for all case in the dynamic network. The proposed method follows a SDN model for finding the Shortest Distances in gradient search estimation was formulated using three algorithms, namely Resource Allocation, Searching algorithm and Distributed Power Efficient Scheduling algorithm based on the identified network path in SDN. According to the experimental results the proposed algorithm mainly focused on SDN based caching and computing time using MATLAB R2013a platform. The achieved DEJRA-CG has less distance variation with less computation time when comparing to Building the Dependency Graph and software-defined networking, caching, and computing (SD-NCC) algorithms.

***Keywords*—** Networking, caching, computing, resource allocation, energy efficient

I. INTRODUCTION

Software defined networking (SDN) is a new paradigm in networking that manages the entire network at the conceptually centralized programmable software controller. With the central view, the controller can manage network flows more efficiently and dynamically. SDN provides fine-grained network configuration dynamically adaptable to the network condition. In the traditional network, the control plane is placed on top of the forwarding plane in each network device. The discrete decision is made by each switch based on the information gathered from the neighbor devices in a distributed matter. Although the network information is shared among devices, the decision is made solely by each device which can increase the complexity and behavioral unpredictability of the entire networks.

Network management is critical to provide fast, reliable and secure network services. Software-defined networking (SDN) is new network architecture to simplify network management by integrating network control to a centralized control platform. Software Defined Networking (SDN) is a relatively new paradigm for network management that is based on the principle of detaching the packet process (Data plane) from the routing process (Control Plane). As the use of SDNs expands, new needs are arising and so are doing new opportunities to fulfill them. The creation of new tools to cover necessities in the field of security and monitoring was the original purpose of this investigation line.

Network management includes many different tasks. Network operators configure network devices, e.g., switches and routers, to realize these tasks. The packet processing in network devices can be modeled as match-action processing where the network devices match on certain patterns of packet headers (e.g., destination IP address belongs to an IP prefix) and perform some actions (e.g., drop packets or forward packets to an output port) on the matched packets. To referred to the forwarding behavior of a switch as a policy of the switch. Similarly, to refer to the network-wide forwarding behavior as a policy of the network, this is built from policies of all switches in the network. Policies change over time, because operators need to reconfigure network devices in face of various network events, such as traffic shifts, cyber attacks, device failures, host mobility, etc. Here, to use some concrete examples to illustrate network management tasks.

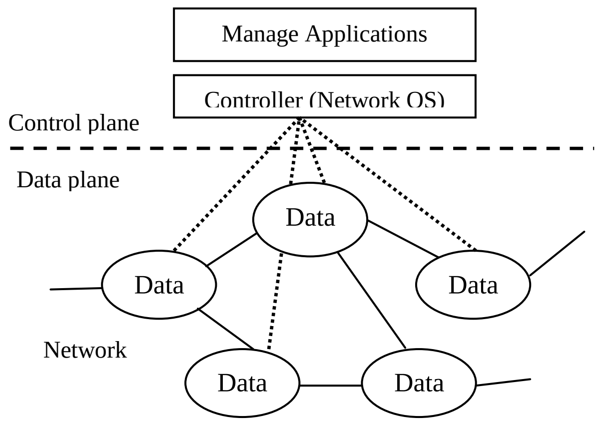

Figure 1. Network management with Software-Defined Networking (SDN)

Software-Defined Networking (SDN) emerged in recent years to fundamentally change how to design, build and manage networks. It has the following distinct features from today's network architecture. Decoupled control plane and data plane: SDN decouples the control plane from the data plane, as shown in Figure 1.

In this paper, presents a Distributed efficient joint resource allocation using conjugate gradient method (DEJRA-CG) in SDN domain with joint resource allocation networking, caching, and computing resources to efficiently meet the requirements of different applications and improve the end-to- end system performance.

The main contributions of this paper are as follows:

- Resource Allocation and Distributed Power efficiency scheduling with optimal conjugate gradient Method in the downlink of SDN networks supporting Routing selection in MATLAB simulation.

II. RELATED WORK

***J. Baliga, R. W. A. Ayre, K. Hinton, and R. S. Tucker* (2011)** [1] presented an analysis of energy consumption in cloud computing. The analysis considers both public and private clouds, and includes energy consumption in switching and transmission as well as data processing and data storage. To showed that energy consumption in transport and switching can be a significant percentage of total energy consumption in cloud computing. Cloud computing can enable more energy-efficient use of computing power, especially when the computing tasks are of low intensity or infrequent. However, under some circumstances cloud computing can consume more energy than conventional computing where each user performs all computing on their own personal computer (PC).

***N. Choi, K. Guan, D. C. Kilper, and G. Atkinson* (2012)** [2] investigated the minimum energy consumption that CCN can achieve with optimal cache locations by considering different caching hardware technologies, number of downloads per hour, and content popularity. The first set up an energy consumption model for CCN and then formulate linear and nonlinear programming problems to minimize total energy consumption of CCN. Also, a genetic algorithm (GA) approach is proposed to find energy-efficient cache locations. Using reported energy efficiency of computational hardware and network equipment, to showed CCN yield greater energy savings for very popular content and small-sized catalog, compared to conventional CDN.

***S. Salsano, et.al,* (2013)** [3] proposed and discussed solutions to support ICN by using SDN concepts. They focused on an ICN framework called CONET, which grounds its roots in the CCN/NDN architecture and can interwork with its implementation (CCNx). Although some details of the solution have been specifically designed for the CONET architecture, its general ideas and concepts are applicable to a class of recent ICN proposals, which follow the basic mode of operation of CCN/NDN. They discussed approach the problem in two complementary ways. First they discuss a general and long term solution based on SDN concepts without taking into account specific limitations of SDN standards and equipment.

***A. Chanda and C. Westphal* (2013)** [4] presented Content Flow, an Information-Centric network architecture which supports content routing by mapping the content name to an IP flow, and thus enables the use of Open Flow switches to achieve content routing over a legacy IP architecture. Content Flow is viewed as an evolutionary step between the current IP networking architecture, and a fully fledged ICN architecture. It supports content management, content caching and content routing at the network layer, while using a legacy Open Flow infrastructure and a modified controller. In particular, Content Flow is transparent from the point of view of the client and the server, and can be inserted in between with no modification at either end.

***B. Wang, Y. Zheng, W. Lou, and Y. T. Hou* (2014)** [5] examined the security impact, in particular, the impact on DDoS attack defense mechanisms, in an enterprise network where both technologies are adopted. To find that SDN technology can actually help enterprises to defend against DDoS attacks if the defense architecture is designed properly. To that end, authors proposed a DDoS attack mitigation architecture that integrates a highly programmable network monitoring to enable attack detection and a flexible control structure to allow fast and specific attack reaction. To cope with the new architecture, to proposed a graphic model based attack detection system that can deal with the dataset shift problem.

***D. Kreutz, F. Ramos, P. E. Veríssimo, C. E. Rothenberg, S. Azodolmolky, and S. Uhlig* (2015)** [6] presented a comprehensive survey on SDN. To start by introduced the motivation for SDN, explain its main concepts and how it differs from traditional networking, its roots, and the standardization activities regarding this novel paradigm. Next, to present the key building blocks of an SDN infrastructure using a bottom-up, layered approach. To provided an in-depth analysis of the hardware infrastructure, southbound and northbound APIs, network virtualization layers, network operating systems (SDN controllers), network programming languages, and network applications. They also looked at cross-layer problems such as debugging and troubleshooting. In an effort to anticipate the future evolution of this new paradigm, discuss the main ongoing research efforts and challenges of SDN.

***G. Liu, F. R. Yu, H. Ji, and V. C. M. Leung* (2016)** [7] introduced the idea of wireless virtualization into FDR cellular networks. Then, the problem of energy-aware virtual resource management is formulated as a three-stage Stackelberg game. The subgame perfect equilibrium for each stage is analyzed. In addition, the interplays of the three stage game are discussed and an iterative algorithm is proposed to obtain the Stackelberg equilibrium solution.

***B. Wang, W. Song, W. Lou, and Y. T. Hou* (2017)** [8] start from a practical system model of the personalize medicine and present a solution for the secure DNA sequence matching problem in cloud computing. Comparing with the existing solutions, the scheme protects the DNA data privacy as well as the search pattern to provide a better privacy guarantee. They have proved that the scheme is secure under the well-defined cryptographic assumption, i.e., the sub-group decision assumption over a bilinear group. Unlike the existing interactive schemes, the scheme requires only one round of communication, which is critical in practical application scenarios. They also carry out a simulation study using the realworld DNA data to evaluate the performance of the scheme. The simulation results show that the computation overhead for real world problems is practical, and the communication cost is small. Furthermore, the scheme is not limited to the genome matching problem but it applies to general privacy preserving pattern matching problems which is widely used in real world.

***Q. Chen et al.,* (2017)** [9] propose a novel framework that jointly considers networking, caching and computing techniques in order to improve end-to-end system performance. This integrated framework can enable dynamic orchestration of networking, caching and computing resources to meet the requirements of different applications. To defined and develop the key components of this framework: the data plane, the control plane, and the management plane. The data plane consists of the devices that are responsible for networking, caching and computing operations. The control plane has a logically centralized controller to guide these operations. The management plane enables not only traditional applications, such as traffic engineering, but also new applications, such as content distribution and big data analytics. Simulation results are presented to show the effectiveness of the proposed framework.

***Qingxia Chen, et.al.,* (2018)** [10] described the recent advances in jointing networking, caching, and computing and present a novel integrated framework: software-defined networking, caching, and computing (SD-NCC). SD-NCC enables dynamic orchestration of networking, caching, and computing resources to efficiently meet the requirements of different applications and improve the end-to-end system performance. Energy consumption is considered as an important factor when performing resource placement in this paper. Specifically, to studied the joint caching, computing, and bandwidth resource allocation for SD-NCC and formulate it as an optimization problem. In addition, to reduce computational complexity and signaling overhead, they proposed a distributed algorithm to solve the formulated problem, based on recent advances in alternating direction method of multipliers (ADMM), in which different network nodes only need to solve their own problems without exchange of caching/computing decisions with fast convergence rate.

III. METHODOLOGY

In this paper, proposed a novel Distributed efficient joint resource allocation using conjugate gradient method (DEJRA-CG) in distributed network caching based SDN algorithm within an incomplete group of cells.

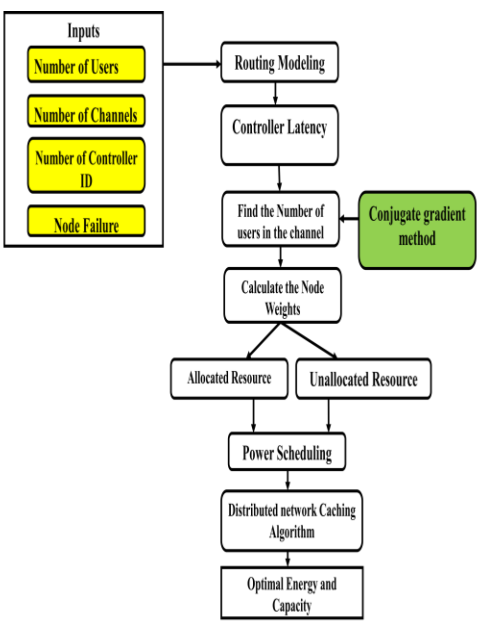

Figure 2. Flow Diagram of proposed system

The Proposed System considers the Resource Allocation and Distributed Power efficiency scheduling with optimal conjugate gradient Method in the downlink of SDN networks supporting Routing selection in MATLAB simulation. The purpose of Resource Allocation is to allocate sub-carriers and power to users to meet their service requirements, while maintaining fairness among users and maximizes resource utilization using synthetic dataset. The flow diagram of proposed system is described in figure 1.

A. *Network Modelling*

In the network model, they system assume that mobile nodes are situated inside a disk with radius *R*. They are distributed uniformly with density *d*. In addition, mobile nodes communicate with each other at a uniform rate λ. The network and traffic load are symmetric in the intelligence that all mobile nodes of the similar distance *dt* from the centre of the network are similar, i.e. the quantity of load available through all mobile nodes, which are of a permanent distance r from the centre, is the same.

Let consider a network model with n nodes where n is in the order of 30 to 50. A node has a location (*x*, *y*) considered from several orientation point. All mobile nodes are implicit to be in the identical plane. Every mobile node has the similar deterministic, constructive and restricted communication range r. In additional words, two nodes *P* and *Q* are directly connected (or neighbors) if and only if

$$d(P,Q) = \sqrt{(x_{P-}x_Q)^2 + (y_{P-}y_Q)^2 < r} \quad (1)$$

Where *d* (*P*, *Q*) denotes distance among two mobile nodes. This involves that the message channels are symmetric, (i.e., if *P* is a neighbor of *Q*, *Q* is a neighbor of *P* and associate versa).

B. *Resouce Allocation*

The Resource Allocation is determined at the base-station as a function of the perceived signal strength of each user on each sub-carrier as well as the user requested rate, in the uplink environment, after the allocation is conveyed to the user (assume the implicit presence of such a mechanism).

A Resource Allocation is one telecommunication signal carrier that is carried on top of another carrier so that effectively two signals are carried at the same time. A subcarrier is a separate analog or digital signal carried on a main radio transmission, which carries extra information such as voice or data. More technically, it is an already-modulated signal, which is then modulated into another signal of higher frequency and bandwidth. This is an early and simple method of multiplexing. The first step of the algorithm initializes all the variables. Rk keeps track of the capacity for each user and

N is the set of yet unallocated subcarriers. The second step assigns to each user the unallocated subcarrier that has the maximum gain for that user. The advantage is gained by the users that are able to choose their best subcarrier earlier than others, particularly for the case of two or more users having the same subcarrier as their best. The third step proceeds to assign sub-carriers to each user according to the greedy policy that the user that needs a subcarrier mostly used in iteration gets to choose the best subcarrier for it. The fourth step assigns the remaining unassigned sub-carriers to the best users for them, wherein each user can get at most one unassigned subcarrier. This is to prevent the user with the best gains to get the rest of the subcarriers. This policy balances achieving proportional fairness while increasing overall capacity.

C. Gradient Search Estimation

The Greedy Search Power Allocation algorithm can be applied in solving the optimization problem during resource allocation. For the research assume the parameter for the candidate modulation, where the thresholds are obtained through simulation. In order to obtain the maximum throughput across all these N sub-carriers, Greedy algorithm can be taken advantage. The problem can be seen as a problem with global optimization, and Greedy algorithm can help achieving the global optimization with a lot of local optimization.

In the initialization step, all the sub-carrier is allocated with 0 bit. And the required additional power with one additional bit for all sub-carriers can be calculated. The local optimization is to allocate one bit to the sub-carrier with the least required power. Hence, the 1st sub-carrier is allocated with 1 bit. And the required additional power with one additional bit for it is updated. In the second allocation, the 3rd sub-carrier obtains the least required additional power. Hence it is allocated with 1 bit. The processes continue until all sub-carriers are allocated with the maximum bits or the power is not enough to support one further bit. When the processes end, the global optimization is achieved and the current allocation is the optimal allocation with the maximum throughput.

D. Distributed Power Efficient Scheduling Algorithm

In conventional SDN systems, given the sum transmit power constraint or the target rate, the optimal power allocation that aims at maximizing the sum rate or minimizing the required power can be achieved by the well-known water-filling algorithm. In SDN-based distributed systems, the power allocation should also satisfy the sub-channel transmit power constraints which are introduced by the interference power limits of the PUs. Therefore, the power allocation algorithm needs to be modified.

IV. Results and Discussion

The proposed work believes a 50 to 500 nodes multi-hop SDN network, with mobile nodes arbitrarily deployed in a 1000 m x 1000 m region. The resource node and target nodes of every session are arbitrarily selected, with the path connecting the shortest paths.

Figure 3 shows the impact of average requests arriving rate on the performance of different scenarios. In this case, the halves of the total requests are content requests and the other half are computation requests. The average energy consumption reduction gives of existing Building the dependency graph, software-defined networking, caching, and computing (SD-NCC) and proposed distributed efficient joint resource allocation using conjugate gradient method (DEJRA-CG) in table 1.

Table 1. The Average Energy Consumption Reduction

Methods	1000	2000	3000	4000	5000	6000
Building the Dependency Graph	0.005	0.1	0.25	0.26	0.3	0.32
SD-NCC	0.005	0.1	0.25	0.26	0.39	0.42
DEJRA-CG	**0.006**	**0.15**	**0.28**	**0.32**	**0.42**	**0.46**

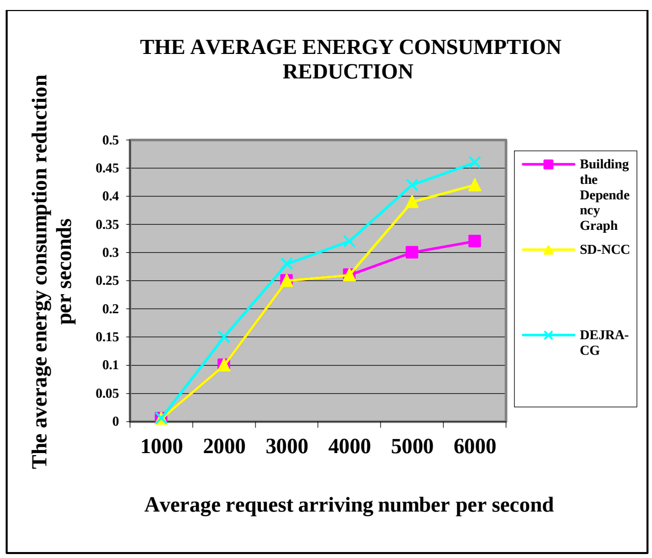

Figure 3. Achievable average energy consumption size under BDG, SD-NCC and DEJRA-CG

In Fig. 3, the more coming requests, the more requests served on the in-network server nodes, thus the more network usage reductions.

Table 2. Average Network Usage Reduction Per Second With Different Requests Arriving Rates

Methods	**1000**	**2000**	**3000**	**4000**	**5000**	**6000**
Building the Dependency Graph	0.2	0.72	0.8	0.85	0.89	0.91
SD-NCC	0.35	0.76	0.86	0.88	0.93	0.94
DEJRA-CG	**0.54**	**0.82**	**0.89**	**0.93**	**0.95**	**0.96**

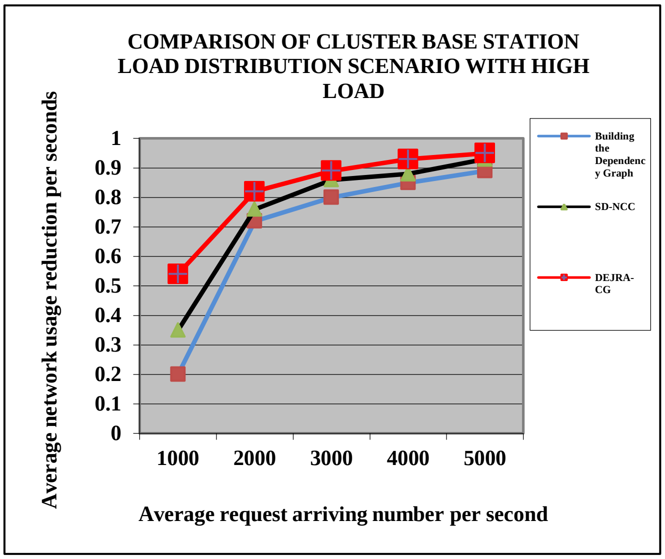

Figure 4. Achievable Average network usage reduction per second under BDG, SD-NCC and DEJRA-CG

V. Conclusion

In this paper, presents a Distributed Efficient Joint Resource Allocation Using Conjugate Gradient method (DEJRA-CG) algorithm The SDN controller manages the network flows dynamically and individually with the global view of the entire network. Its dynamic controllability has led to significant benefits in SDN mobility where in essence the requirements and the utilization change dynamically on demand. To perform extensive experiments to evaluate the proposed algorithm and the results demonstrate the efficiency of our algorithm. Through the experimental models, the proposed research algorithm verify that the DEJRA-CG method attains significantly better achievable throughput and average energy consumption than predictable methods such as a Building the Dependency Graph and SD-NCC based algorithms.

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