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High Performance Network Optimization

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Abstract: The term "big data" was coined to describe the vast amounts of information science and technology data that have been generated on a large scale over time. Based on existing research, the current state of the problem was observed, i.e. "Poor internet speed, network downtime, constant traffic jams, energy consumption due to increasing internet connectivity, which increases management overhead costs, network unavailability". Therefore, this research provides a brief overview of the list of bandwidth optimization models applied through previous research works, indicating the optimal algorithms that work with each of the models in formulating a new bandwidth optimization model that solves the mixed integer linear programming technique problem which was the approach adopted from the existing works. necessary for wireless networks. This paper aims to evaluate and analyze existing bandwidth optimization models, optimal algorithms with each model, as well as a new bandwidth optimization model that solves the problem of previous optimization techniques. In wireless networks, the most energy-consuming activities are network bandwidth transmission and reception. Energy consumption for data transmission or reception depends on the volume of network traffic and the speed of network traffic from source to destination.

Keywords: *Network optimization, high performance networks, bandwidth, algorithms.*

Introduction

An important feature of bandwidth optimization systems is to adequately provide Internet service with high data rates and wide coverage. Low bandwidth causes poor Internet speed, network lag, constant network traffic congestion, and network unavailability during Internet use. Existing research on bandwidth optimization focuses on bandwidth allocation in creating different channels and traffic to guarantee good quality of service (QoS). Despite several optimization techniques and bandwidth allocation algorithms of existing researchers, they still operate with increased energy costs of network devices and other infrastructure. One of the serious problems of optimization techniques is that of the problem of mixed integer linear programming. When describing high-performance networks, operator networks are called "high-performance" networks (Arya & Sharma, 2018). The subject of our research is the analysis of existing optimization models, their characteristics, advantages and disadvantages, and a proposal for their improvement. The goal of our research is to evaluate and analyze existing bandwidth optimization models, optimal algorithms with each model, as well as a new bandwidth optimization model that solves the problem of previous optimization techniques. Despite the fact that technology is increasingly advanced every day, we still deal with low bandwidth, network latency, and network traffic congestion. In our research, we will analyze existing methods and technologies used to improve high-performance networks. Based on the reviewed literature, we can set two hypotheses that we will try to prove through research:

(H1): Existing bandwidth optimization models have low bandwidth and therefore network latency and network traffic congestion occur.

(H2): By improving the performance of the information system and cluster architecture, we will solve the problems with network bandwidth and data processing.

The reason I decided to do scientific research is because, despite technological advances, network traffic congestion and low bandwidth still occur, and I have not come across any recent research that has addressed this topic in the Republic of Serbia.

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Methods

In our research, we used the comparative and the case study method and described them with the descriptive method as a set of empirical research techniques. We used a research tool based on the available literature and described the research with the descriptive method based on the analyzed data.

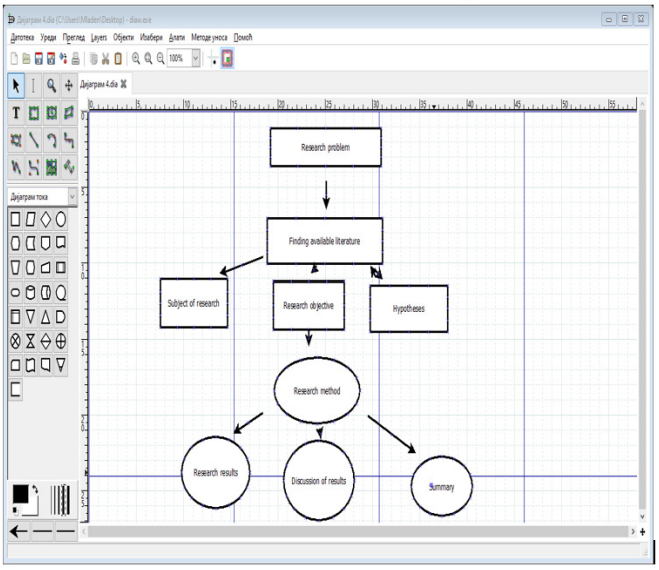

Diagram 1. Research flow chart

Initializing enables each Internet Protocol (IP) address to work smoothly, and optimization leads to high-quality data transmission simultaneously from the sender to the recipient and vice versa, such as audio or video files (Park, Lee & Sung, 2006). Since the 20th century and the advancement of the Internet network as well as rapid advancement of computer technology, the popularity of high-performance computers, and the data transmission model in Internet traffic, there have been revolutionary changes in big data transmission technology. The development of technology and Internet applications also faces significant difficulties due to the impact of a large number of network users and complex data in traffic (Li, et all., 2018). The lack of network bandwidth in the data center computer is the main factor leading to this problem (Li, Zhang, Chen, & Xiang, 2018). It is necessary to improve the performance of the information system and cluster architecture, solve the problems of network bandwidth and data processing to create more efficient data traffic.

Results

The client-server architecture was used when the Internet was first launched. In such a model, bandwidth is consumed very quickly. Local caching on the client side was introduced as a partial solution (Oriato, Girdlestone, & Mencer, 2015). Data is cached and used at the proxy (Oluwatobi & Oludele, 2013) level and has shown success (Paxson, & Floyd, 1995). After that, cooperative caches such as the Internet Protocol for Caching and Routing Cache Array (Reddy et all., 2018) were introduced. Mutual synergy was also presented and applied as a solution. CDN technology has evolved to be one of the main frontiers in solving the bandwidth consumption problem. All previous solutions are application-level solutions. A proposed bandwidth optimization algorithm in GPS servers with multiple classes of service in which we can minimize bandwidth while satisfying different QoS requirements for each queue class in a multi-queue system (Alalibo, et all., 2020). Since it is difficult to analytically evaluate the performance for Internet traffic with similar and dependent distances and characteristics, the performance was evaluated mainly using simulations. Specifically, a fluid simulation was performed instead of a packet-level simulation to reduce complexity. The bandwidth optimization algorithm was based on the outer function method, using the relationship between the allocated bandwidth vectors and the performance obtained from the fluid simulation. The bandwidth optimization implies an outer function, which takes a long time to converge because it uses many simulations to obtain the direction and magnitude vectors. Therefore, the input class velocity in the fluid flow model is constant in unit time interval length (Wu et all., 2018). An improved information application system is proposed by optimizing the fine integration method using

fractional differential equations and combining it with software-defined networking (SDN) to address the issues related to network bandwidth of previous information application systems that cannot guarantee the quality of large data transmission, resulting in low transmission efficiency and slow data processing. The optimization formula for adaptive selection of parameters N and increased number q is developed using error analysis theory. An improved information application system is created when SDN is used, and the improved algorithm and system are found using performance tests and simulation examples. The results show that the improved method possesses higher numerical accuracy and computational efficiency with the improved algorithm. Also, compared with previous systems, the improved port data connection speed and task completion efficiency are much higher. The model was implemented on a working network center and finally, the developed prototype was evaluated using the simulation tool OMNET++. The existing literature related to bandwidth monitoring and optimization systems was reviewed using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method.

The existing bandwidth research led to identification of optimization problems and they were categorized into various metrics, approaches and systems used by researchers. The shortcomings in the system throughput were discovered. New mathematical integration equations based on time series routing were derived. Based on two discrete time series of input data for bandwidth optimization based on antimeridian (AM) and primeridian (PM), the formula is given: In the existing works, the energy consumption of the system, E, depends on the energy consumption of the device, R, which changed with time, t. If T was the duration for a certain period then the energy provided by:

$$\mathrm{E}\,(\mathrm{T}) = \int_0^T P(T)\,dt$$

As a result of the gaps registered and observed in the formulas for the existing works as applied in (i) follows,

• The existing formula concentrated on the power consumption of network devices while omitting the power consumption rate of wireless devices.

• The existing formula focuses on the AC power supply of network devices only and omits the DC power source especially when there is a power outage due to any circumstances.

• The am/pm timer relay was not ultimately integrated because the previous mathematical model only applied to am/pm, and omitted the automatic switching of the NO-NC switch as a result of the am timer relay.

In turn, a new mathematical equation was developed which is known as the Energy Cost Savings by Bandwidth Reduction Equation (ESCRBE).

Discussion

Bandwidth allocation and management are crucial for meeting the quality of service (QoS) needs of applications and improving the user-centricity of network architectures. Knowing that bandwidth is a limited resource, artificial intelligence techniques have already progressively replaced traditional bandwidth allocation methods. The development of wireless technology has resulted in the emergence of applications, protocols, and scenarios used by human efforts. This serves various applications, services, and transmissions, the scalable and reliable communication networks they require. Sensor networks, machine-to-machine communication, millimeter wave techniques, multiple-input multiple-output technologies, and many recent developments have helped to increase the efficiency of communication and data transmission over wireless networks. The user-centric paradigm based on the quality of experience (QoE), which is decided by the QoS provided by the network, is becoming increasingly prevalent in mixed networking situations.

In their publications, researchers discussed a number of algorithmic techniques that could reduce network routing execution time, energy consumption, and latency. Peer-to-peer networks were provided with good network services, a flexible network between users. For data transmission, the bandwidth from source to destination was expanded. In addition, the amount of unavailable bandwidth was reduced. Researchers used techniques to maximize bandwidth and transfer rate during data transmission in an equal period of time. To meet the quality of service (QoS) needs of applications and support the switchover of network architectures, bandwidth allocation and management are crucial. Data throughput begins to slow down as the traffic volume approaches the network capacity. By default, new packets will be dropped if a buffer queue appears on an interface that reaches capacity. Switches and routers can use Quality of Service (QoS) to queue and service higher priority traffic before lower priority traffic and to drop lower priority traffic in favor of higher priority during downtime.

During the initialization phase, the PRTG monitoring software is activated to monitor the initial network hosts and provides analysis based on date/time, network traffic and its volume, network traffic speed, network downtime, and network coverage metrics based on energy consumption. Once the PRTG monitors the network hosts, the am/pm timer relays will be activated by the PRTG monitoring sensors via the network administrator. Furthermore, normally open/normally closed switches are then activated via the AM/PM timer relay to turn on the active wireless link (border gateway) of the router and turn off the passive wireless (border) router until the host bandwidth network is congested, then the process is reversed. This process is called the Energy Saving and Cost Reduction Control Model (ESCRCM). The bandwidth optimization model is represented by mixed integer programming which is used to solve mathematical equations involving the integration of AM/PM timer relays that activate no/nc and include active and inactive modes (from 12 PM to 12 PM and also from 12 PM to 12 PM). Different algorithms developed for bandwidth optimization techniques vary in accuracy when applied to other bandwidth optimization models.

Based on the conducted scientific research, we can confirm the first hypothesis that existing bandwidth optimization models have low bandwidth and cause network downtime and network traffic congestion, which is why they need to be improved. Based on the conducted scientific research, we can confirm that by improving the performance of the information system and cluster architecture, we solve problems with network bandwidth and data processing.

Conclusion

We can conclude that EEBMOM was developed using bandwidth optimization techniques, these techniques had five methods which were hardware compression, deduplication, object caching, traffic shaping and forward error correction. The model was formulated using bandwidth optimization techniques (BO) while the collected data was combined with three algorithms: FUE-sub-channel matching algorithm (FSMA), Joint sub-channel and power allocations algorithm (JSPA), and integrated structure cabling system (ISCS) algorithm. Based on existing research, the current state of the problem, i.e. “poor internet speed, network downtime, constant traffic jams, energy consumption due to increasing internet connectivity, which increases management overhead costs, network unavailability”. Based on the above, we see that there is a great need for network optimization because the failure of network optimization affects business, increases business costs and leads to network unavailability. In practice, the remaining bandwidth problem is very important for telecommunications companies that provide us with internet network services because network downtime leads to the inability to use the internet and user complaints. In addition, we live in a time when it is almost impossible to function normally without a fast and affordable internet network, which is needed not only for user entertainment but also for healthcare, the Ministry of Defense, companies and all other users of internet traffic. As soon as our research has finished, we can give a proposal for improving bandwidth that can be achieved by further researching the current state of existence optimization, optimal algorithms of optimization models and a data intensive model using mathematical formulas.

References

Alalibo, T. J., Orike, S. U. N. N. Y., & Elechi, P. R. O. M. I. S. E. (2020). Bandwidth Optimization of Wireless Networks Using Artificial Intelligence Technique. *Iconic Research and Engineering Journals, 3*(9), 125-130. https://www.irejournals.com/formatedpaper/1702018.pdf

Arya, R., & Sharma, S. C. (2018). Energy optimization of energy aware routing protocol and bandwidth assessment for wireless sensor network. *International Journal of System Assurance Engineering and Management, 9*, 612-619. https://doi.org/10.1007/s13198-014-0289-3

Li, J., Zhang, Y., Chen, X., & Xiang, Y. (2018). Secure attribute-based data sharing for resource-limited users in cloud computing. *Computers & security, 72*, 1-12. https://doi.org/10.1016/j.cose.2017.08.007

Li, P., Li, J., Huang, Z., Gao, C. Z., Chen, W. B., & Chen, K. (2018). Privacy-preserving outsourced classification in cloud computing. *Cluster Computing, 21*, 277-286. https://doi.org/10.1007/s10586-017-0849-9

Oluwatobi, A., & Oludele, M. Kofi (2013). ,,A Study of Network Optimization Models for High-Performance Networks”, ResarchGete.

Oriato, D., Girdlestone, S., & Mencer, O. (2015). Dataflow computing in extreme performance conditions. In *Advances in Computers 96*, pp. 105-137. Elsevier. https://doi.org/10.1016/bs.adcom.2014.11.002

Park, W., Lee, J. Y., & Sung, D. K. (2006, June). Bandwidth optimization algorithm based on bandwidth ratio adjustment in generalized processor sharing servers. In *2006 IEEE International Conference on Communications 2*, pp. 699-703. IEEE. https://doi.org/10.1109/ICC.2006.254789

Paxson, V., & Floyd, S. (1995). Wide area traffic: the failure of Poisson modeling. *IEEE/ACM Transactions on networking, 3*(3), 226-244. https://doi.org/10.1109/90.392383

Reddy, R., Pavan, V., Reddy, D., Manikanta, R., & Chandra, I. (2018). Bandwidth optimization using different algorithm techniques in wireless sensor networks. *International Journal of Advance Research, Ideas and Innovations in Technology, 4*(6), 187-191. https://www.ijariit.com/manuscripts/v4i6/V4I6-1234.pdf

Wu, J., Dong, M., Ota, K., Li, J., & Guan, Z. (2018). Big data analysis-based secure cluster management for optimized control plane in software-defined networks. *IEEE Transactions on Network and Service Management, 15*(1), 27-38. https://doi.org/10.1109/TNSM.2018.2799000