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A Survey on Bandwidth Management Techniques Via the OSI Model Network and Application Layers

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Abstract

Nowadays, virtually all the basic aspects of human endeavor is computer and network dependent. Therefore bandwidth being one of the most valued resource and component of any network must be properly managed to yield a reliable performance. Over the years, different algorithms, models, techniques and applications have been developed for network and bandwidth management yet bandwidth problems has persistently remained on the increase. This work is an in-depth survey on the causes of bandwidth problems, the basic models and techniques for bandwidth management and is followed by an analysis which is aimed at yielding meaningful suggestions on how a better technique or method for securing an efficient and improved bandwidth management solution using the application layer of the OSI network model can be achieved.

Index terms— network, OSI models, techniques, bandwidth, bandwidth management, layer(s), internet, administrator.

A Survey on Bandwidth Management Techniques Via the OSI Model Network and Application Layers I. Introduction owadays, almost every endeavor of human daily lives depend primarily on computers and related devices which in turn are based on networks. Domestic, official, social, financial, economic, religious and many other human activities have all become computer and network based. Also, these activities when carried out with the computer have been proved to be more successful and cheaper when computer networks get involved. Computer networks on its side, requires data bandwidth for its operation and functionality. Bandwidth is a very essential but expensive network resource which must be properly managed to provide the maximum required throughput expected by the network owners and the network users. The lack of or improper management of a network to conserve bandwidth results to network crisis or failure.

1 a) Requirements for a Good Network

Like every other project, a network projects must have a proper design for the network to survive expansion after deployment. According to ANAND (2005), good networks do not happen by accident rather good networks are the result of hard work by network designers and technicians, who identify network requirements and select the best solutions to meet the needs of a business. Network users generally do not think in terms of the complexity of the underlying network. They think of the network as a way to access the applications they need, when they need them. A few of the requirements to achieve a good network have been identified to include the following; i. A network should stay up all the time, even in the event of failed links, equipment failure, and overloaded conditions. ii. Every network should reliably deliver applications and provide reasonable response times from any host to any host. iii. A network should be secure. It should protect the data that is transmitted over it and data stored on the devices that connect to it. iv. A network should be easy to modify to adapt to network growth and general business changes. v. Because failures occasionally occur, troubleshooting should be easy. Finding and fixing a problem should not be too time-consuming.

The statements above fall in line with Sunjay Sharma (2011) recommendations for a manageable network to be achieved.

2 b) Network Management

Network management is the process of manipulating resources of a network such as bandwidth, storage, etc. in other to improve the performance of the network.

Over the years, various techniques andmodels of layered architecture has been employed to either, administer, manage and or secure computer networks. John S. et al. (2011),in a study on the causes of failure in internet access delivery in Nigerian university libraries, observed that planning and eventual management of the bandwidth of a computer network is always a challenging task yet, networks must be properly managed to provide efficiency, throughput and good quality of service (QoS). Layering which implies the division of one whole network process into smaller tasks where each of the small task is then assigned to a particular layer which works dedicatedly to process only that task. Layering idea has been greatly employed in managing network and its complex and important resources like bandwidth.

3 d) Network Bandwidth

Bandwidth is a very important network resource and plays a very key factor in networking. Bandwidth can be defined in variety of ways depending on the context. In computing, bandwidth can be defined as; the bit-rate of available or consumed information capacity in a network and expressed typically in metric multiples of bits per second (bps). Bandwidth may be characterized as network bandwidth, data bandwidth or digital bandwidth. Behrouz (2013) defined bandwidth as a range within a band of frequencies or wavelengths while Devajitet al. (2013)defined bandwidth in computer networking as, a reference to the data rate supported by a network connection or interface.

4 e) Bandwidth Management Challenges

Bandwidth is one of the most required and most expensive components of the internet today. It is a general knowledge that the higher the available bandwidth, the better the performance of their networks but this is not always true rather actually dependent on certain factors viz;

i. The cost of bandwidth is a major cost of network and most organization obtain as much as they can only afford rather than as they need. But most times, the users' demand on bandwidth exceeds the capacity of their link causing saturation and leading to network poor performance. ii. Most network face the challenge of bandwidth misuse and abuse causing such networks to surfer from bandwidth insufficiency or vulnerability of their networks. iii. Some networks are not managed at all. Reference Sara gywnn (2013) stated categorically that most research centers and educational institutions in Africa and the developing world are not managed at all thereby causing network failures and sometimes the extinction of such networks. iv. Avister (2009) alsoproved that although most people assume that internet congestions is only on the link to the internet, but congestion is mainly in the incoming direction. Therefore, the significance of bandwidth in a network cannot be overemphasized and suggest that there is the need for efficient bandwidth management systems and models in every network.

5 f) Significance of Bandwidth Management

In order to meet the objectives of organizations and internet users, internet usage must be managed to achieve the following; 1. To control the expensive cost of bandwidth 2. To proffer good network performance and efficiency for critical and useful applications 3. To enable the use of non-critical applications when resources are available 1. Limiting the non-critical traffic in such a way that it does not affect the necessary critical traffic 2. Bandwidth traffic attempts to separate the critical traffic from the non-critical in other to achieve 1 above.

6 It also aims at providing sufficient resources traffic

for areas deemed critical by the network owner 4. To carry non-critical traffic on the basis of resource availability. 5. To limit the usage of unauthorized applications within the network. 6. To limit the size of bandwidth usage and avoid waste.

In order to achieve these outlined objectives of bandwidth management, the various techniques employed by different network owners, administrators and users to manage bandwidth apart from the measures considered during the planning and design of a network can be categorized into four main follows;

7 a) Restriction of Internet Usage Technique

This technique implies placing a restriction on those users, group of persons or applications from accessing the available bandwidth by means of software embedded in a routers and seems to be more effective in providing security. Most internet users in organizations only require to access their corporate intranet and email. Such users should be restricted from accessing the internet rather may be provided with web machine for their occasional internet need since not providing internet access to those who do not need it for corporate functions improves the network security. Also, access restriction include the prevention of unauthorized users and non-critical applications from accessing the bandwidth. This is a sure way of improving network bandwidth and security. Sometimes, users are equipped with applications that are not necessary for their corporate function and they end up wasting bandwidth and causing network traffic hugs. For example running streaming media, social media

and torrent download in a corporate environment. Such should be restricted to improve network performance by reducing unnecessary traffic in the network. Access restrictions are implemented by assigning private IP addresses (e.g. 192.168.xx.xx) to users, none use of se network address translation (NAT) and through channeling web access via a proxy server. Access restriction can be summarized as taking administrative measure to prevent unauthorized bandwidth usage.

8 Fig. 2: Restriction of internet usage technique b) Time Shift Internet Usage

This bandwidth management technique uses ftp (file transfer protocol) and web mirror servers to upload files on to the server at night which can be accessed by day. It applies off-line downloading where large files downloads are queued for off-peak hours. User are requested on appeal to shift their internet usage time and this technique often yields low success.

9 c) Managing multiple connections

This is another technique used for managing bandwidth. Obviously, managing a single network is a lot easier than managing multiple sites but many sites use multiple connections as a result of cost and reliability problems. It is ideal to share network load proportionally among multiple connections but it is easier to control outing traffic as against in coming traffic because of the difficulty of managing the dynamic assignment of IP addresses from different connections to different group of users. Border Gateway Protocol (BGP) is a standardized exterior gateway protocol designed to exchange routing and reachability of information among autonomous systems. BGP is difficult to configure for managing multiple connections and requires the co-operation of the ISPs involved as well as the services of an expert to configure it. Furthermore, multiple connections bandwidth management technique is done using NAT and use of proxies with multiple IPs apportioned to the IP.

10 d) Network Layer Bandwidth Management

The network layer of the OSI network model is responsible for address assignment and the unique addressing of hosts in a network using the IP network protocol to route messages using the best path available. Bandwidth management at the network layer operates as a real time management technique by processing data packets as they arrive. Managing bandwidth at the network layer involve network traffic also called data traffic which refers to the amount of data moving across a network at a given point of time as stated by Jianguo (2013). Network data is mostly encapsulated in network packets which provide the load in the network. Network traffic is the main component for network traffic measurement, network traffic control and simulation. The proper organization of network traffic helps in ensuring the quality of service (QoS) in a given network. The QoS techniques of Integrated Services (Intserve) and differentiated services (Diffserve) can be used to manage bandwidth since it has to do with data traffic. QoS is used to provide service to applications at the required quality by checkmating data loss, delay and jitter to manage and make efficient use of bandwidth to meet organization's needs. QoS and bandwidth management have similar objectives except that QoS is real-time and only applicable at the network layer while bandwidth management can be done using different techniques at different layers of the OSI model to achieve the required objectives. QoS uses packet classification, queuing disciplines, packet discard policies, policing and shaping as to perform bandwidth management functions. Conclusively, one can include QoS in a bandwidth management system by configuring QoS in a router to control outgoing traffic as far as the internet link is not congested. Incoming traffic is though difficult to control using this technique. Bandwidth management at the network layer is traffic control based using a router as illustrated in Fig. **??**.1.

11 i. Bandwidth allotment model (BAM)

Bandwidth allotment model was the first bandwidth modelling management model developed and was used in a triggered dynamic bandwidth management mechanism **??**15].

ii. Bandwidth Constraint Models One of the goals of DiffServ or MPLS traffic engineering is to guarantee bandwidth reservations for different service classes. For these goals two functions are defined

12 iii. Static Bandwidth Allocation

This management technique allocates maximum bandwidth level to each class and uses traffic-shape or rate-limit command to control the data traffic. If a class uses less than the allocated bandwidth, it is not restricted but if the class attempts to use more than the allocated bandwidth, it is limited. If total allocations is less than or equal to the available BW then all allocations can be satisfied. Otherwise, Total allocation ids greater that the available bandwidth.

13 iv. Dynamic Bandwidth Allocation

In dynamic bandwidth allocation policy-map and bandwidth or priority commands are used to provide limited bandwidth only when link is congested. The classes are not subjected to limitation only when the link is not congested.

14 v. Bandwidth Reservation

Bandwidth reservation is another allocation method which is based on priority of a class. The remaining bandwidth can then be allocated to none priority classes. It is best used when a fixed bandwidth is required for priority or critical traffic.

15 e) Limiting Non-priority Traffic

This is done allocating Small bandwidth nonpriority traffic classes while the remaining available bandwidth is left for the priority traffic. The method is suitable when traffic is variable and the priority traffic does not require unnecessarily limitation.

i. Priority Queuing This method gives priority to the priority class and sends traffic to others only if the link is free. They remain in que until there is no traffic requirement from the priority class. control browsing speed of clients in a network using a proxy server [9]. Reference [9] further stated that in computer networks, a proxy server may be a computer system or an application which serves as an intermediary between servers sought after by clients. Proxy servers are hosts systems which relays web access requests from clients. They are used when clients do not have direct access to the web to improve security, logging, accounting and performance in networks.

16 Fig.2.2: Proxy Server used for bandwidth and other management

Caching and storing copies of recently accessed web pages for faster data access is another method of managing bandwidth. It enable pages to be delivered from the cache when requested for again. The pages are stored in browser caches and or proxy caches and manage bandwidth by;

? providing shorter response time to data ? reduced bandwidth requirement from users or client ? reduced load on servers thus increasing their efficiency ? providing network access control and logging

? Some examples of proxycache include; Apache proxy, MS proxy server and Squid.

17 III. Application Layer Bandwidth Management

Network application layer techniques for bandwidth management is another bandwidth management techniques which has been proved by recent research to be one of the most critical areas that can be used to improve bandwidth management and provide efficient network performance yet it has been observed to be the least area that has been researched in solving bandwidth or network management problems. According to Avister (2009), Youngzsoft (2015) and Ronget al. (2010),different application have been developed and distributed for managing network at the application layer while more are still undergoing development for use as network based bandwidth management applications. New network technologies are emerging and network usage is also growing very rapidly such that today, almost all organizations and individuals cannot work without the internet which is the largest network as stated by Kassimet al. (2012). Networks provide better communications, transfers of data and information, businesses through cloud computing and many more. These needs have resulted in the development of more applications to meet up with the need of these services. The application tools need to be monitored for business purposes and must prioritize the network bandwidth as it should be used since internet bandwidth usage ranks top among other network application needs.

Application layer bandwidth management (BWM) allows for the creation of policies which regulate bandwidth consumption by specific file types within a protocol, while allowing other file types to use unlimited bandwidth. This enables a network administrator to distinguish between desirable and undesirable traffic within the same protocol. Application layer bandwidth management is supported for all Application matches, as well as custom App Rules policies using HTTP client, HTTP Server, Custom, and FTP file transfer types.

18 a) Firewalls

Firewalls are usually configured to manage bandwidth at global or WAN levels. Bandwidth management modelling using the network applications layer which was based on a comparative study on five recent research on this subject, it was and discovered that each of them used a different mathematical equation to model the bandwidth management method in a network [12]. Reference [12] survey showed that apart from the use of firewall and "Big pipe" approaches to manage network and bandwidth, different recent researches adopted different model, algorithms or techniques in solving either network or bandwidth management problems at the application layer of the OSI model which have also been agreed as the best layer for bandwidth management even though bandwidth management problems still exists.

19 b) Application Bandwidth Management

Application bandwidth management (ABM) is the collection of a set of Quality of Service (QoS) tools used to manipulate and prioritize data traffic by application type thereby preventing bandwidth-intensive applications, such as peer-to-peer applications like BitTorrent from crowding or taken over legitimate business traffic in a network.

Dan Dinicolo (2013) mentioned that, advanced bandwidth management solutions are employed to maximize an organization's available bandwidth through carrying out inspections and classifying the generated traffic by common business applications based on granular policies, and ensuring that the most critical network traffic receives the highest priority across WAN links.

Solutions provide automatic application protocol classification and comprehensive policies and traffic controls such as rate shaping, rate limiting, selective dropping and priority marking.

20 c) Application Protocol Classification

Application protocol Classification involves Deep Packet Inspection (DPI) techniques which will enable bandwidth management devices to identify application protocols not withstanding whether those applications use deceptive port-hopping, porttunnelling, and encryption techniques to avoid detection or not.

21 d) Innovative User-Based QoS Policies

This technique allocate bandwidth and network application access transparently to network users solely on the bases user IDs or using traditional QoS policies with respect to Layer 3-7 traffic classifications.

22 e) Bandwidth Utilization Reports

Bandwidth utilization reports are used to quickly identify top protocols, and find users that are consuming too much bandwidth with a view of managing and effectively utilizing the available bandwidth on a network.

23 f) Internet Access Bandwidth Management Techniques

Internet Access Management is one of the resource management techniques and is often based on using the network applications layer to conserve bandwidth in a network.

24 IV. Analysis of the Existing Bandwidth Management Applications

All the existing different BWM models and techniques used for network bandwidth management which were x-rayed in section IIIproved to be efficient but each of the model, techniques of algorithm lacked in certain aspects therefore failed to provide total bandwidth management due to one or two deficiencies as follows.

25 a) Lack of Security in Some Models

One of the major challenges facing modern networks management is security. Security begin with the users in a network to other threats from outside the network especially through the internet. An unsecured or an insecure network is prone to bandwidth wastage, misuse and other network problems which can affect bandwidth most especially when the network user causing the problem remains unidentifiable.

26 b) Non-Consideration of Human Factors on Management

All the existing bandwidth management methods reviewed did not consider the human intervention / user involvement in both using and managing bandwidth as necessary parameters to be considered in order to secure an efficient bandwidth management in a network. It can be seen that biometric parameters can have serious effect on bandwidth but are not considered by the various techniques for bandwidth management reviewed.

27 c) Specialization of Management

The network layer techniques considered data traffic as the major parameter for bandwidth management while the application layer management techniques considered filter and bandwidth allotment based on classes or policies as the possible methods for bandwidth management. These alone cannot yield complete bandwidth management.

28 d) Lack of Biometric Impact

In almost every network management practice, the facial identity, department, position, job title are not deemed necessary for user account creation. Most often, only a User name, user ID and password are the only identification and authorizations considered when creating user accounts in most network. The implication is that the network admins most often do not have access or opportunity of seeing or physically identifying who is using or doing what in their networks. Therefore such practices like impersonation, stealing a user ID or masquerading a user can easily grant network access to an unauthorized user who may misuse bandwidth and malicious activities

which can eventually cause harm to the network. Also, an authorized user in a large network may tend to waste or misuse bandwidth when he or she cannot be physically identified.

29 e) Recommendations for Good Bandwidth Management Model

Based on the analysis of this survey, the following recommendations are suggested to be included in any bandwidth management application to proffer bandwidth or network management efficiency. The development of a hybrid model or system that will encompass the features of the various application layer models applied for bandwidth management. c) The inclusion of an automatic and immediate feedback system to any bandwidth management system with the capability of using the mac address of every user who attempts to gain entrance to a network but fails after two attempts. The user will only be able to login after a biometric or physical identification is made by the admin.

In conclusion, of an audit trail system that is capable of always monitoring the activities of high end bandwidth users.

V.

30 Conclusion

Despite improvements in equipment performance and media capabilities, network design is becoming more and more difficult as networks are expanding on daily basis due to the digital age. The trend is toward increasingly complex environments involving multiple media, multiple protocols, and interconnection to networks outside any single organization's dominion of control. Carefully choosing the most appropriate model in designing networks can reduce the hardships associated with growth as a networking environment evolves. Choosing the appropriate network model must not be overlooked because, it is a prerequisite for a network design and the eventual management of a network and its resources. Different bandwidth management technique and models were surveyed with respect to the layers of the OSI network model. The survey showed that the application layer bandwidth management techniques was recommended by most researchers as the most effective for bandwidth management not withstanding some minor problems which this survey observed to have resulted basically from the non-inclusion of human parameters in the various application layer models surveyed. In conclusion, to curb network and bandwidth management problems, with human being traffic generators and bandwidth users, human factors and influence on bandwidth must be considered by any model before a very efficient bandwidth management solution can be achieved. The survey recommend the development of a model or algorithm which will use the application layer to manage bandwidth while considering bandwidth allocation, sharing methods and using organizational policies based on human biometric and influence to manage networks. [1] [2] [3]

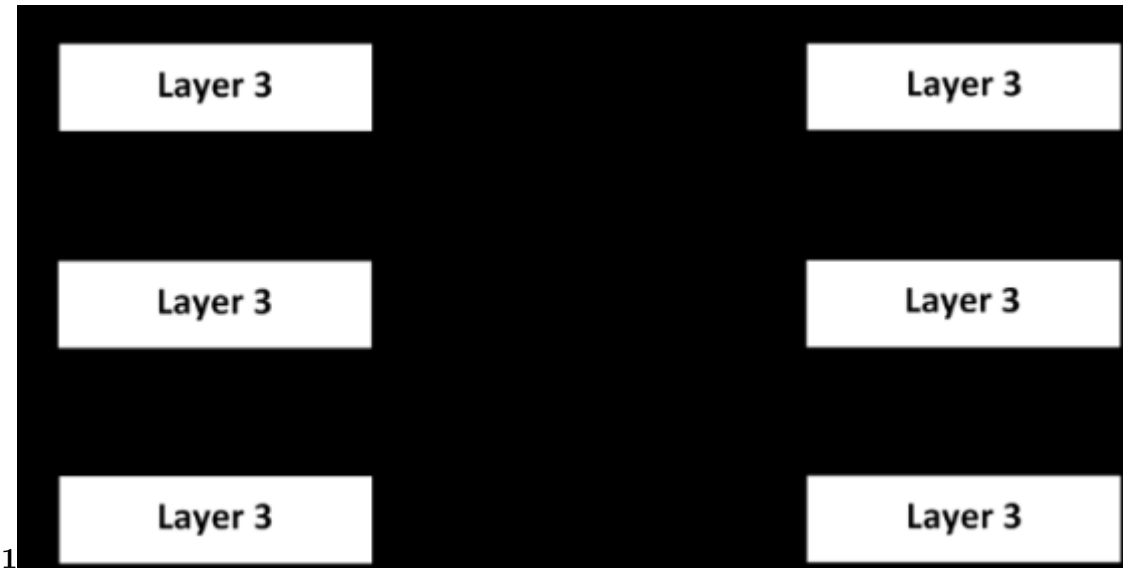

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Figure 1: Fig. 1 :

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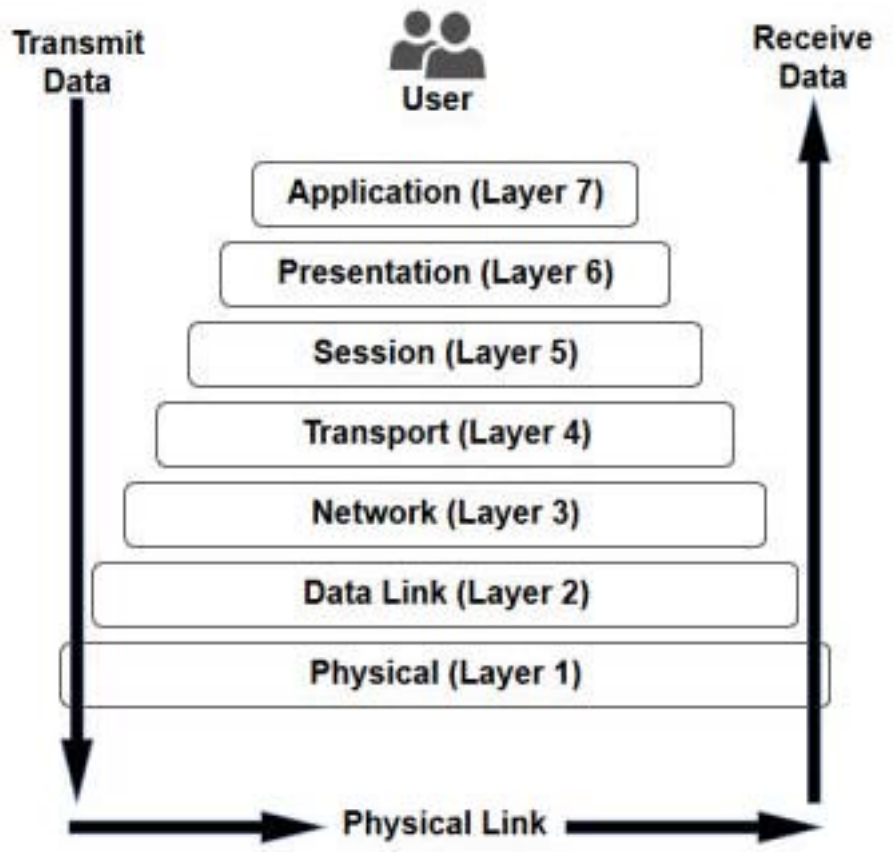

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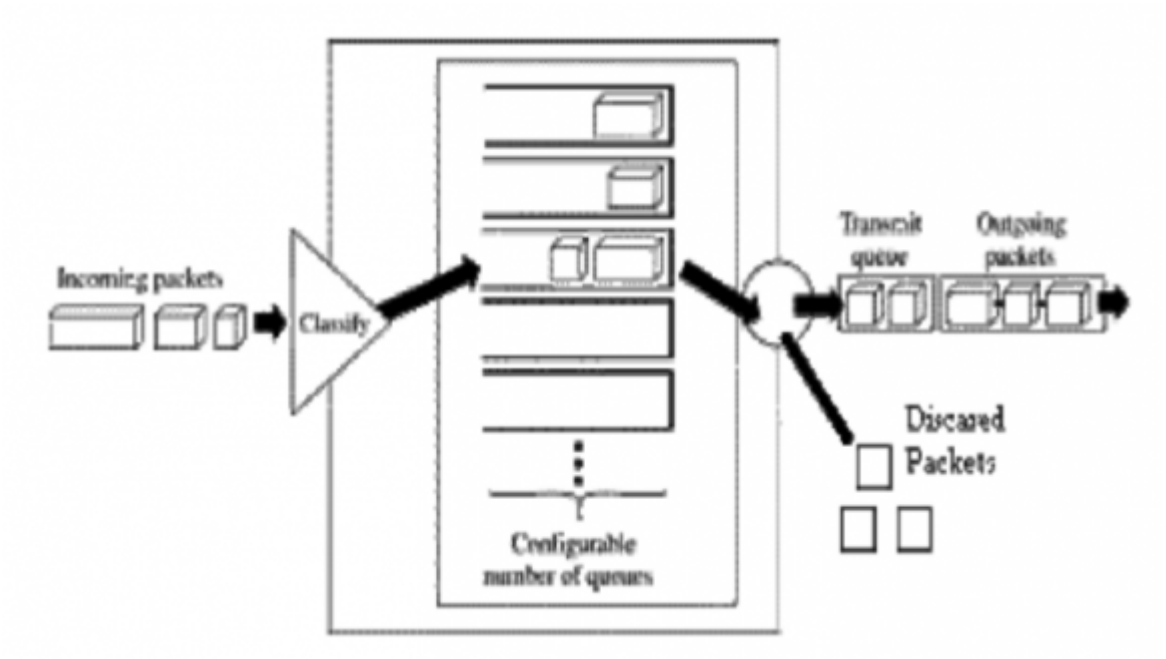
Figure 2: Fig. 1 . 2 :



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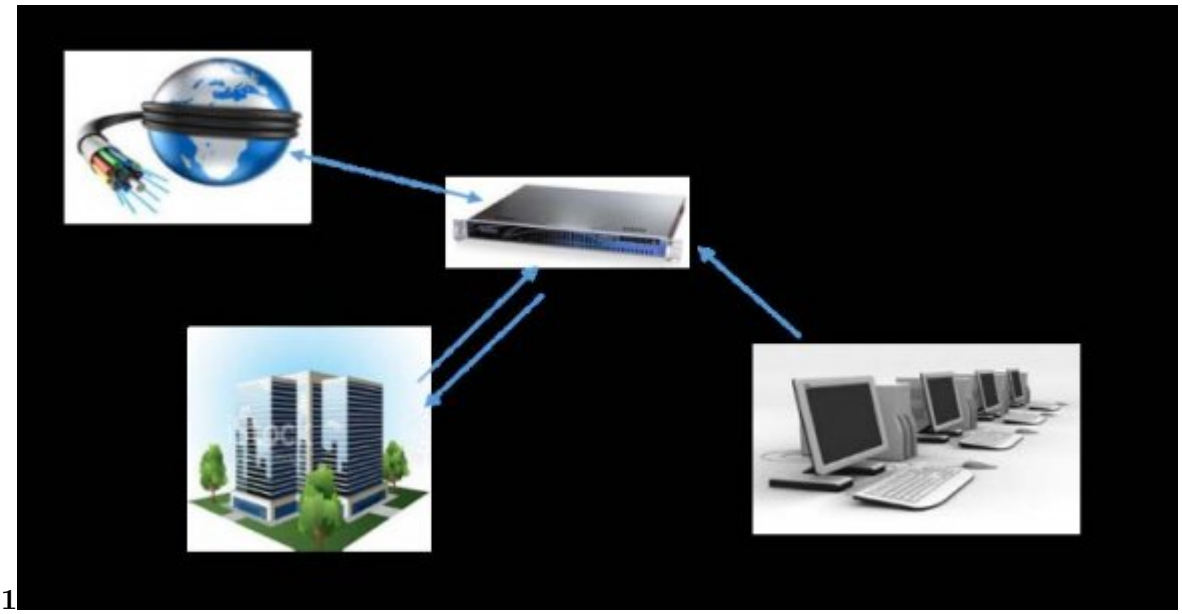

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Figure 4: Fig. 2 . 1 :

Figure 5:

Figure 6:

[Dinicolo (2000)] , Dan Dinicolo . 2013. 2000Trainers. August 23rd 2016.

[Reale1 et al. (2013)] , Rafael F Reale1 , Romildo M Da , S Bezerra2 , S B Joberto , Martins . November 2013.

[Sharma ()] *A course in computer networks (Principles,Technologies and Protocols)*, Sunjay Sharma . 2011. p. . (OSI reference model and network architecture. First Edition)

[Devajit et al. ()] 'A study of bandwidth management in computer networks'. M Devajit , A Majidul , J Utpal . *International Journal of Innovative Technology and Exploring Engineering* :2278-3075Vol-2 issue 2. 2013. p. .

[Advances in network management International Standard BookNumber ()] 'Advances in network management'. 978-1-4200-6455-1. *International Standard BookNumber* 2013. CRC Press. 13 p. . Tylor&Francis Group (Jianguo Ding)

[Cao and Yeng ()] *Bandwidth Management in Computer Networks2010*, H Cao , G Yeng . `http//netmag.edu/~poi/clepis233/ebook/index.htm` 2010.

[Behrouza and Forouzan ()] *Data communications and networking 5E, Introduction Global Edition*, Behrouza , Forouzan . 2013. p. .

[Kassim et al. ()] 'International scholarly and scientific research & innovation'. M Kassim , M Ismail , K Jumari , YusofJ . *World Academy of Science, Engineering and Technology* 2012. 6 (2) p. .

[John et al. ()] 'Managing and Improving Upon Bandwidth Challenges in Computer Network'. S John , R E Okonigene , V O Matthews , B Akinade , I Chukwu . *Journal of Emerging Trends in Engineering and Applied Sciences* 2011. 2 (3) p. . (JETEAS))

[Sousa A. Viana (ed.) ()] *Metaheuristics: Computer decision Making Applied Optimization Series*, Sousa & A. Viana (ed.) 2010. Norwell, MA, USA: Kluwer Academic Publishers. 68 p. .

[Rong et al. (ed.) ()] *NewBenchmark Instances for the Steiner problems in Graphs*, I Rong , M Aragao , C C Uchoa , R F Werneck . M.G.C. Resende J.P (ed.) 2010.

[Product approach document bandwidth management ()] *Product approach document bandwidth management*, 2009. p. .

[Gywnn (2013)] 'Promoting access and capacitybuilding for scientific information resources'. Sara Gywnn . *IAP Workshop*, (Darker, Senegal) January 2013. p. .

[Youngzsoft (2015)] Youngzsoft . `http://youngzsoft.net/ccproxy/manageebandwidth.htm` *Retrieved from*, July 2015.

[Wireless Hotspots: Current challenges and future directions, mobile networks and applications ANAND ()] 'Wireless Hotspots: Current challenges and future directions, mobile networks and applications'. *ANAND* 2005. 10 p. .