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A Comparative Analysis of Server Base Operating System Performance in a Network Environment

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ABSTRACT
In this paper, in a laboratory environment the performance of four different operating systems (Windows NT4, Windows 2000, Windows 2003, and Linux Fedora) are compared. The performance parameters measured are bandwidth and network delay. Linux Fedora provided the highest bandwidth for a file server at 17.1Mbps, Windows 2000 was fastest for a FTP (83.2Mbps), and Windows 2003 and Windows 2000 gave the highest bandwidth for a web server (4.3Mbps and 4.5Mbps respectively).

I. INTRODUCTION

A computer system has many resources (hardware and software), which may be require to complete a task. The commonly required resources are input/output devices, memory, file storage space, CPU etc. The operating system acts as a manager of the above resources and allocates them to specific programs and users as necessary for their task. Therefore operating system is the resource manager i.e., it can manage the resource of a computer system internally(Pothumani & Hameed Hussain, 2017). The resources are processor, memory, files, and I/O devices.

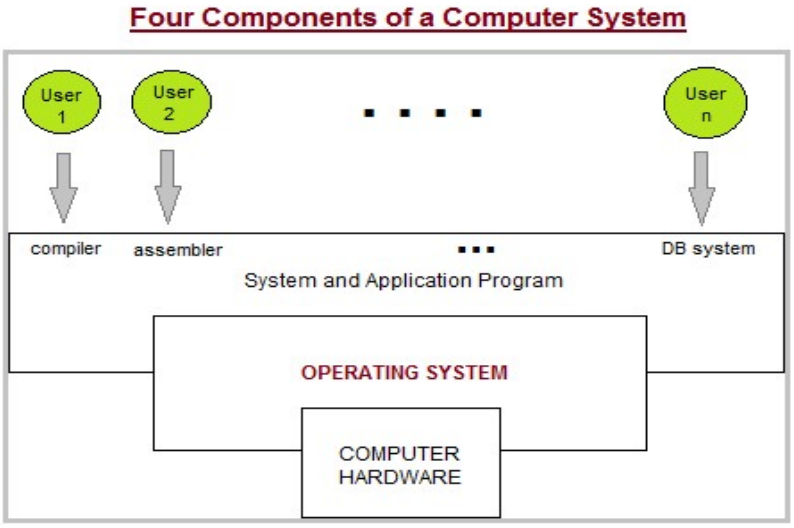

Fig.1 Component of a computer system

1.1 Overview of Operating System

1.1.1 User View: - The user view of the computer refers to the interface being used. Such systems are designed for one user to monopolize its resources, to maximize the work that the user is performing. In these cases, the operating system is

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designed mostly for ease of use, with some attention paid to performance, and none paid to resource utilization(Silberschatz, Peterson, & Galvin, 1991).

1.1.2 System View: - Operating system can be viewed as a resource allocator also. A computer system consists of many resources like - hardware and software - that must be managed efficiently. The operating system acts as the manager of the resources, decides between conflicting requests, controls execution of programs etc.

1.1.3 Operating System Management Tasks

(i) Processor management which involves putting the tasks into order and pairing them into manageable size before they go to the CPU.

(ii) Memory management which coordinates data to and from RAM (random-access memory) and determines the necessity for virtual memory.

(iii) Device management which provides interface between connected devices.

(iv) Storage management which directs permanent data storage.

(v) Application which allows standard communication between software and your computer.

(vi) User interface which allows you to communicate with your computer(Silberschatz et al., 1991).

1.1.4 Functions of Operating System

i. It boots the computer.
ii. It performs basic computer tasks e.g., managing the various peripheral devices e.g., mouse, keyboard.
iii. It provides a user interface, e.g., command line, graphical user interface (GUI).
iv. It handles system resources such as computer's memory and sharing of the central processing unit (CPU) time by various applications or peripheral devices.
v. It provides file management which refers to the way that the operating system manipulates, stores, retrieves and saves data.
vi. Error Handling is done by the operating system. It takes preventive measures whenever required to avoid errors (Code, 1992).

1.1.5 Types of Operating Systems

Following are some of the most widely used types of Operating system.

i. Simple Batch System
ii. Multiprogramming Batch System
iii. Multiprocessor System
iv. Distributed Operating System
v. Real-time Operating System

1.1.6 Network Operating Systems

A modern O/S contains much built-in software designed to simplify networking of a computer. Typical O/S software includes an implementation of TCP/IP protocol stack and related utility programs like ping and trace route. This includes the necessary device drivers and other software to automatically enable a device's Ethernet interface. Mobile devices also normally provide the programs needed to enable Wi-Fi, Bluetooth, or other wireless connectivity(Reddy, Kumar, Janakiram, & Kumar, 2009).

Early versions of Microsoft Windows did not provide any support for computer networking. Microsoft added basic networking capability into its operating system starting with Windows 95 and Windows for Workgroups. Microsoft also introduced its Internet Connection Sharing (ICS) feature in Windows 98 Second Edition (Win98 SE), Windows Home Group for home networking in Windows 7, and so on. Contrast that with UNIX, which was designed from the beginning with networking in view. Nearly any consumer O/S today qualifies as a network operating system due to the popularity of the Internet and home networking(Sinha, 1992).

1.1.7 Server (computing)

In computing, a server is a computer program or a device that provides functionality for other programs or devices, called "clients". This architecture is called the client–server model, and a single overall computation is distributed across multiple processes or devices. Servers can provide various functionalities, often called "services", such as sharing data or resources among multiple clients, or performing computation for a client. A single server can serve multiple clients, and a single client can use multiple servers. A client process may run on the same device or may connect over a network to a server on a different device. Typical servers are database servers, file servers, mail servers, print servers, web servers, game servers, and application servers(Sinha, 1992).

Client–server systems are today most frequently implemented by (and often identified with) the request–response model: a client sends a request to the server, which performs some action and sends a response back to the client, typically with a result or acknowledgement. Designating a computer as "server-class hardware" implies that it is specialized for running servers on it(Sinha, 1992). This often implies that it is more powerful and reliable than standard personal computers, but

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alternatively, large computing clusters may be composed of many relatively simple, replaceable server components.

1.1.8 Operation

A network based on the client–server model where multiple individual clients request services and resources from centralized servers. Strictly speaking, the term server refers to a computer program or process (running program). Through metonymy, it refers to a device used for (or a device dedicated to) running one or several server programs. On a network, such a device is called a host. In addition to server, the words serve and service (as noun and as verb) are frequently used, though servicer and servant are not. The word service (noun) may refer to either the abstract form of functionality, e.g., Web service. Alternatively, it may refer to a computer program that turns a computer into a server, e.g., Windows service. Originally used as "servers serve users" (and "users use servers"), in the sense of "obey", today one often says that "servers serve data", in the same sense as "give". For instance, web servers "serve [up] web pages to users" or "service their requests"(Swift, Bershad, & Levy, 2005).

The server is part of the client–server model; in this model, a server serves data for clients. The nature of communication between a client and server is request and response. This is in contrast with peer-to-peer model in which the relationship is on-demand reciprocation. In principle, any computerized process that can be used or called by another process (particularly remotely, particularly to share a resource) is a server, and the calling process or processes is a client. Thus, any general-purpose computer connected to a network can host servers. For example, if files on a device are shared by some process, that process is a file server. Similarly, web server software can run on any capable computer, and so a laptop or a personal computer can host a web server.

While request–response is the most common client–server design, there are others, such as the publish–subscribe pattern. In the publish–subscribe pattern, clients register with a pub–sub server, subscribing to specified types of messages; this initial registration may be done by request–response. Thereafter, the pub–sub server forwards matching messages to the clients without any further requests: the server pushes messages to the client, rather than the client pulling messages from the server as in request–response.

When referring to hardware, the word server typically designates computer models specialized for their role. In general, a server performs its role better than a generic personal computer.

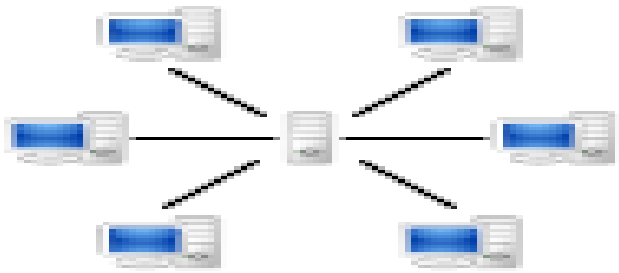

Fig. 2 A network based on the client–server model where multiple individual clients request services and resources from centralized servers

1.1.9 Purpose of Severs

The purpose of a server is to share data as well as to share resources and distribute work. A server computer can serve its own computer programs as well; depending on the scenario, this could be part of a quid pro quo transaction, or simply a technical possibility(Yādava, 2009). The following table shows several scenarios in which a server is used.

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Table 1. Taxonomy of servers based on their types, purpose and clients

Server type	Purpose	Clients
Application server	Hosts web apps (computer programs that run inside a web browser) allowing users in the network to run and use them, without having to install a copy on their own computers. Unlike what the name might imply, these servers need not be part of the world wide web; any local network would do.	Computers with a web browser
Catalog server	Maintains an index or table of contents of information that can be found across a large distributed network, such as computers, users, files shared on file servers, and web apps. Directory servers and name servers are examples of catalog servers.	Any computer program that needs to find something on the network, such a Domain member attempting to log in, an email client looking for an email address, or a user looking for a file
Communications server	Maintains an environment needed for one communication endpoint (user or devices) to find other endpoints and communicate with them. It may or may not include a directory of communication endpoints and a presence detection service, depending on the openness and security parameters of the network	Communication endpoints (users or devices)
Computing server	Shares vast amounts of computing resources, especially CPU and random-access memory, over a network. Any computer program that needs more CPU power and RAM than a personal computer can probably afford.	The client must be a networked computer; otherwise, there would be no client–server model.
Database server	Maintains and shares any form of database (organized collections of data with predefined properties that may be displayed in a table) over a network.	Spreadsheets, accounting software, asset management software or virtually any computer program that consumes well-organized data, especially in large volumes
Fax server	Shares one or more fax machines over a network, thus eliminating the hassle of physical access	Any fax sender or recipient
File server	Shares files and folder, storage space to hold files and folders, or both, over a network	Networked computers are the intended clients, even though local programs can be clients
Game server	Enables several computers or gaming devices to play multiplayer games	Personal computers or gaming consoles

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Mail server	Makes email communication possible in the same way that a post office makes snail mail communication possible	Senders and recipients of email
Media server	Shares digital video or digital audio over a network through media streaming (transmitting content in a way that portions received can be watched or listened as they arrive, as opposed downloading a whole huge file and then using it)	User-attended personal computers equipped with a monitor and a speaker
Print server	Shares one or more printers over a network, thus eliminating the hassle of physical access	Computers in need of printing something
Sound server	Enables computer programs of a computer to play sound and record sound, individually or cooperatively	Computer programs of the same computer
Proxy server	Acts as an intermediary between a client and a server, accepting incoming traffic from the client and sending it to the server. Reasons for doing so includes content control and filtering, improving traffic performance, preventing unauthorized network access or simply routing the traffic over a large and complex network.	Any networked computer
Web server	Hosts web pages. A web server is what makes world wide web possible. Each website has one or more web servers.	Computers with a web browser

1.1.10 Network Environment

A network environment is nothing more than Server Computer whereby:

- **Server computers:** Computers that provide shared resources, such as disk storage and printers, as well as network services, such as e-mail and Internet access. Server computers typically run a specialized network operating system such as Windows Server 2008 or 2003, NetWare, or Linux, along with special software to provide network services. For example, a server may run Microsoft Exchange to provide e-mail services for the network, or it may run Apache Web Server so that the computer can serve Web pages. In short, the network computer that contains the hard drives, printers, and other resources that are shared with other network computers is called a server. Usually, the most powerful and expensive computers in a network are the servers(Anderson, Korpela, & Walton, 2005). This fact makes sense because every user on the network shares the server's resources. The network environment will not be fulfilled without Client which it receives network service and predict the performance of server computer's services base on the operating system installed.
- **Client computers:** The computers that end users use to access the resources of the network. Client computers are typically located on users' desks. They usually run a desktop version of Windows such as Windows Vista or Windows XP Professional, along with application software such as Microsoft Office. Client computers are sometimes referred to as workstations. The cheaper and less powerful computers in a network are the clients. Clients are the computers used by individual users for everyday work. Because clients' resources don't have to be shared, they don't have to be as fancy. Beyond the analysis of investment incentives, we also present a short case study comparing Windows vs. Linux along three

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dimensions: the client-side, the server-side and the interaction between the client-side and the server-side. We emphasize that the comparison between Windows and Linux is an issue of comparing two competing software ecosystems, not just two products(Matsuda, Fujimoto, & Mitsunaga, 2019). The existing Windows ecosystem of the operating system, applications, application developers and service providers are competing against an emerging ecosystem centered on the Linux operating system. Therefore, in this mini project we are to analyses the performance between two operating systems i.e., Windows and UNIX/Linux to find out which one is more effective.

II. LITERATURE

2.1 Performance Analysis Unix/Linux Vs Windows Server Based Operating System In A Networked Environment

With the increased uses of computer networks, the performance analysis of networks is becoming critical. Businesses need to transfer more data at the minimum amount of time in their LANs and WANs. At the heart of a client-server environment are network operating systems. These modern operating systems contain significantly more embedded features than what their predecessors had; thus, it is necessary to know how they perform with these increased functionalities(Russell & Jacome, 2003). However, comparison of these operating systems is not an easy task as different operating systems have different features and functionality(Abd Aziz, Udzir, & Mahmod, 2014).

There is little work done to compare the performance of network operating systems in terms of delay and bandwidth using a test bed in a laboratory. Vendor sponsored research is available, however results are biased. For example, IT Week Labs indicate that Linux Samba is 2.5 times faster than Windows Server 2003, while Microsoft sponsored research carried out by Veritest found Windows Server 2003 outperforms the counterpart in common aspects of client-server activities. Performance of web related activities have been undertaken by some researchers looking at specific aspects of just web server. Evaluating how subsystem interaction with operating system affects performance has also been researched. (Coarfa, Druschel, & Wallach, 2006) studied how application and operating system perform on different computer processors. Within the scope of related work, our approach is novel in the sense that it measures throughput and delay on a test bed set-up.

III. METHODOLOGY

In this paper, in a laboratory environment the performance of four different operating systems (Windows NT4, Windows 2000, Windows 2003, and Linux Fedora) are compared. The performance parameters measured are bandwidth and network delay.

3.1 Experimental Setup

In a laboratory setting (Figure 3), a LAN network with TCP/IP protocol is set-up and the operating systems were changed in order to compare the results. All computers and servers are connected in star topology to a 10/100 Ethernet switch with 100Mbps UTP links. The setting included a file server, FTP server, Web server, DHCP and DNS server, Domain Controller and a workstation. The hardware specifications for all computers on this network are IBM 8305-HAD machine type, Intel Celeron 2GHz processor, 4GB RAM, and Intel Pro 100S network adaptor. This being a comparative performance measurement study, it is imperative that the test bed infrastructure remains constant for all the operating systems on the test bed infrastructure, each operating system (Windows NT4, Windows 2000, Windows 2003 and Linux Ubuntu) is installed one at a time.

For each, latest patches and services packs were installed in accordance with the vendors' instructions and no optimization of any sort was performed on the setup. Each operating system was also matched with appropriate services and applications (for example, Windows 2003 was matched with IIS version 6 and Linux Ubuntu with Apache version 2.0.49). DNS (for name resolution) and DHCP (for automation of TCP/IP parameters allocation) were also implemented for each operating system.

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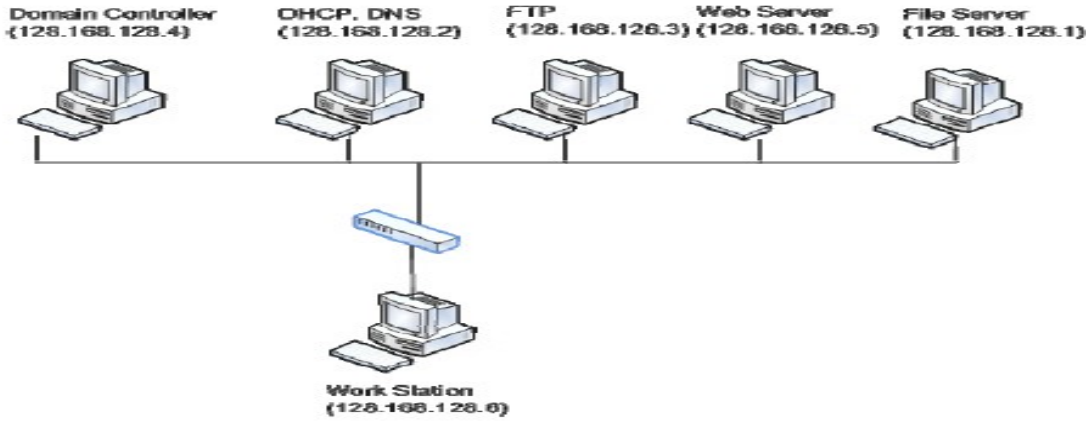

Fig 3. Illustration of the laboratory setup

We used NetBench, WebBench and FTPBench as the primary tools for measuring performance parameters for the network.

3.1.1 NetBench

NetBench measures performance parameters of file servers as it fulfils requests from client computers. This program has been designed for client/server environment; thus, it simulates file transfers of word processed and spreadsheet documents from a file server to workstations.

3.1.2 **WebBench**

WebBench measures similar parameters by generating requests from client workstations to web servers for combination of static files and dynamic executables that run-in order to produce data that the server returns to the client. Web browser is simulated on the workstations which make requests to the server. The client records information such as how long the server took and how much data is returned.

3.1.3 **FTPBench**

works in a similar way to WebBench but uses the GET command to transfer files of various sizes from an FTP server to the workstation. All three programmed stress test the test bed by simulating up to 60 concurrent connections for each operating system.

IV. RESULTS AND DISCUSSION

For various operating systems (Windows NT4, Windows 2000, Windows 2003, Linux Ubuntu) the bandwidth is reported in Table 2. As a file server, the bandwidth recorded for all operating systems were between 16.2Mbps and 17.1Mbps. While Linux Ubuntu marginally performed better than other operating systems, Windows 2000, Windows 2003 and Windows NT4 had close bandwidth. However, as a web server, Windows 2000 and Windows 2003 performed better than the rest with 4.5Mbps while Windows NT4 had the worst performance with only 1.2Mbps. Windows NT4 did not perform well here as it does not have advanced caching that the other operating systems use for web servers. FTP performances of operating systems were Windows 2000 with 83.2Mbps (the best), Windows NT4 with 77.1Mbps and Windows 2003 only at 55.1Mbps (the worst). The FTP test for Linux was 67.5Mbps. Windows 2003 did not perform well with FTP possibly because of increased functionality and features that can sometimes slow the system. The results further show that the actual bandwidth is less than the capacity of the link (100Mbps) and that operating system cannot take full advantage of the link bandwidth. FTP had the highest link usage (77-83Mbps) as FTP is especially made for file transfer while web server had the least link capacity usage of between (1.3 to 3.7Mbps).

Table 2: Comparative results of bandwidth versus operating systems for the four operating systems compared.

	File Server (Mbps)	Web Server (Mbps)	FTP Server (Mbps)
Windows 2000	16.35	4.5	83.2
Windows 2003	16.20	4.3	55.1

Windows NT	16.60	1.2	77.1
Linux Ubuntu	17.1	3.7	67.5

The network delay was also recorded for various operating systems. For file transfer, delay varied from 0.57msec to 0.45msec with Linux providing the least delay as it has the fastest bandwidth for data transfer. As web server, WindowsNT4 creates much delay of 15msec due to low bandwidth of only 1.2Mbps while the network delay of other web servers was between 3.8-4.0msec.

V. CONCLUSION

The performance of four operating systems (Windows NT4, Windows 2000, Windows 2003, and Linux Ubuntu) were compared being used as a file server, web server, or FTP server. The results indicated that Linux Ubuntu provided the best bandwidth as a file server (17.1Mbps) and Windows 2000 for file transfer at 83.2Mbps. Windows 2003 and Windows 2000 at 4.3Mbps and 4.5Mbps respectively were the fastest as a web server while Windows NT4 was the slowest due to caching issues.

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