

Reliability Assessment on the Performance Model of Ahmadu Bello University Data Network Repositories for Storage Area Network Design

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Abstract: As the demand for the consolidation of data stores continues to escalate, a new approach, capable of delivering high bandwidth through multiple and heterogeneous server platforms to a common storage repository at reduced cost, is beginning to emerge. Storage Area Networking (SAN) is an open storage architecture designed to eliminate many of the traditional bottleneck associated with secondary and tertiary storage devices. Calculating the improvement on reliability by using the Redundant Array of Independent Disk (RAID) system associated with 90 data disks divided into 6 groups with each having 15 disks. For this scenario 10 hours ($MTTR_{Disk}$) was considered. The results for the $MTTF_{RAID}$ system was achieved to be 1.56×10^8 hours = **17,836.8** yrs while for a JBOD (Just a Bunch of Disks) having a $MTTF$ parameter of 1.5×10^6 hours (for a typical Fibre channel single disk drive), gives an MTTF value of 16,666.7 hours, or 1.9 yrs. It is now clear that the RAID technology used in the SAN design has a high increase in reliability over the JBOD with over 16 thousand years and has established itself to be of choice in storage repository.

Keywords: Storage Area Networks Implementation, Enterprise Storage Design concept, Storage Repositories, JBOD and RAID Systems, SAN Performance measure.

I. INTRODUCTION

In recent years, enterprise data storage has seen explosive growth in demand from users. This growth is driven by increasingly more sophisticated applications that generate more rich and numerous quantities of content data, and an increasingly larger number of users/consumers of this rich content data. Storage technology has moved from enterprise storage (DAS) to network storage (NAS), and it will keep moving from network Storage to intelligent storage (SAN) which is the core of the network storage technology. Driven by the above requirements, various storage networking technologies have undergone rapid adoption to become the mainstream enterprise solutions [1]. This paper provides a brief introduction to various storage models and technologies. A SAN is dedicated high performance network to move data between heterogeneous servers and storage resources. Being a separate dedicated network it avoids any traffic conflict between clients and servers [2]. Another issue significantly affecting system latency is system scaling what is caused by an ever growing storage data volume as well as occurring disk failures. Furthermore, to obtain the best performance, the newly added disks should also be included into the striping process which gives the advantage of using a RAID over the JOB. Consequently, for low disk failure rates, the failure rate of a disk array is proportional to the number of disks it contains. Any allocation scheme should furthermore provide some certain degree of fault-tolerance. Usually, fault-tolerance is achieved by introducing redundancy into the system. This concept of storage consolidation leads to storage centralized architecture enabling enterprises to facilitate efficient parallel access to the data as well as cost-effective system management. In a SAN, the disk are encapsulated inside advanced storage subsystems, like e.g. disk arrays or high-end enterprise storage cabinets, that today offer a capacity ranging from some TByte to several PByte each.

The RAID array is the module used to represent a complex storage system. The RAID array contains its own I/O controller, interconnections and storage devices. The storage device inside the RAID array can again be a RAID array. When the RAID array is configured to be RAID 5 disk array, multiple dimensions RAID 5 are formed [8].

II. THEORETICAL BACKGROUND

SAN is a dedicated high performance network that moves data between heterogeneous servers and storage resources. Being a separate dedicated network, it avoids any traffic conflict between clients and servers. The Storage Network Industry Association (SNIA) defines the Storage Area Network (SAN) as a network whose primary purpose is the transfer of data between computer terminals and storage elements.

Storage Systems: The DAS storage capacity is limited by the number of HDDs it supports by the bus (e.g. maximum of 15 devices for SCSI). The storage devices include RAID disk arrays, Just a Bunch Of Disks (JBODs), tape systems, Network Attached Storage Systems, optical storage systems etc. The type of interfaces provided on these devices includes SCSI, Fibre Channel, and Ethernet.

Data Sharing: The term *data sharing* refers to accessing the same data from multiple systems and servers. It is often used synonymously with storage partitioning and disk pooling. Data sharing is not a solution that is exclusive to SANs, the SAN architecture can take advantage of the connectivity of multiple hosts to the same storage in order to enable data to be shared more efficiently than through the services of a file server.

Data Availability: As people and enterprises become more and more reliant on the content in the data storage, the reliability and availability of data storage systems networks must be dramatically increased to prevent the severe consequences that may result from loss of data content and loss of access to data.

Disk Sharing File Systems: Impressive improvements in processor and memory performance have not been accompanied by equivalent advances in the performance of input/output subsystems. Aiming to close this gap, striping data across large arrays of disks has been proposed as a technique for improving I/O performance by exploiting the bandwidth of several disks to service a single logical request or multiple independent requests in parallel. Files are therefore striped across a set of I/O nodes into blocks to facilitate parallel access. For each file striped across n I/O nodes, there will be n subfiles, one per I/O block, holding that file's data. When an I/O request a file to be saved into memory, the file is striped into width –characterized as blocks (RAID 5) forming four 4 sub-requests (for 4 blocks e.g.), each one of which is serviced asynchronously by one disk is further striped into l stripe depth (Mean request size (Kbytes)). Figure 1 is a typical disk striping model.

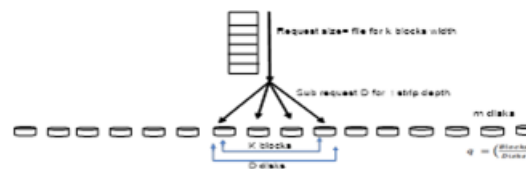


Figure 1: Disk Striping Model

III. RAID RELIABILITY

The Management Information System (MIS) of the University currently has 29,871 undergraduate student and 7,569 postgraduate student data stored in the usable disk space in the Storage Device (SD) of its hosts. The usable disk space will reduce exponentially yearly as more students are being admitted. Averagely 7,109 undergraduate students and 4,198 postgraduate students are being admitted every year within the University. And a total of 18,835 graduate students currently have their profile saved in the cloud technology.

IV. JUST A BUNCH OF DISC (JBOD)

RAID Is a technology to combine multiple small, independent disks drives into an array of a single disk drive. Putting n disk drives together (as in JBOD) results in a system whose failure rate is n times the Failure rate of a single disk making it impractical for addressing the high reliability and large capacity problem of enterprise storage.

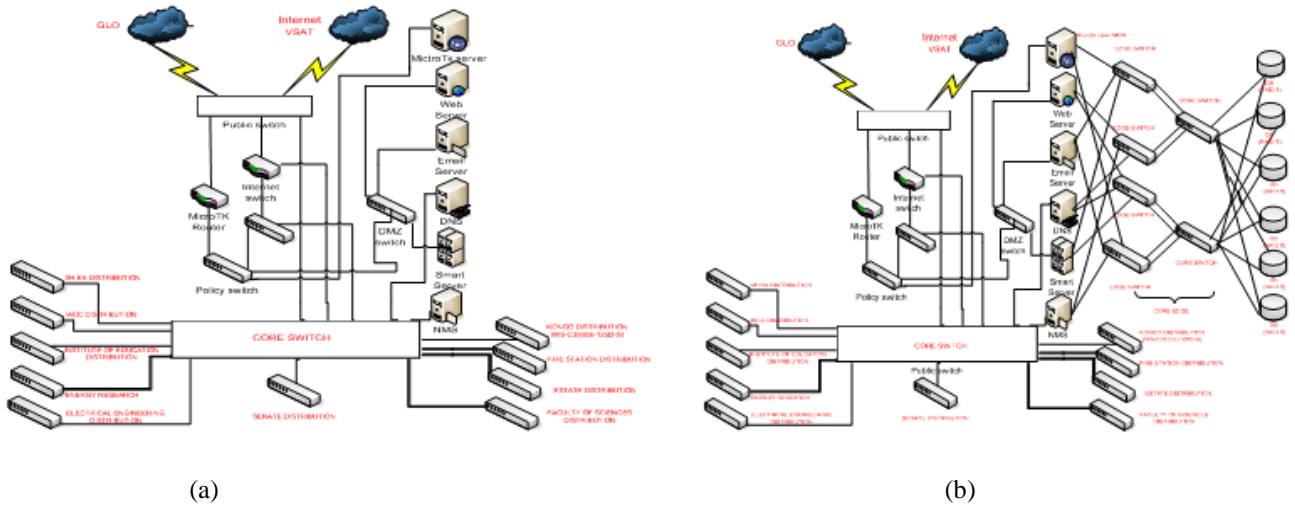


Figure 2: Network Layout (a) Schematic diagram of ABU – Core to Distribution Physical Connectivity (b) The proposed Core-edge SAN fabric design

Figure 2 (a) is the current Schematic diagram of Ahmadu Bello University – Core to Distribution Physical Connectivity while Figure 2 (b) is the proposed core/edge SAN attached; it connects to the Internet via the STM-1 from GLO. Mail and Web Server are on the reduced 2Mbps Internet link via Intelsat by Vsat.

V. THE CORE/EDGE SAN FABRIC DESIGN

ARENA uses event driven method to develop the simulation model. Storages and networks in ARENA are virtualized to upper level in the virtual device concept. The servers are classified as those which send broadcasts across SAN while the databases as those which do not send broadcasts across SAN [7]. Storage capabilities and processing speeds, are excluded from our simulation model. Figure 3 is the SAN design model.

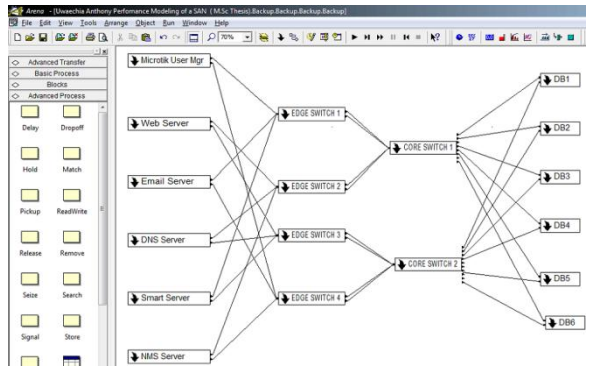


Figure 3: The SAN design Model

The only pertinent features to the network are the rates at which each end-device supplies and demands for data. Therefore the end-devices are all modelled as simply creating and receiving traffic in the form of packets.

VI. VERIFICATION AND VALIDATION OF THE MODEL

Verification of model construction and validation of the model was done to ensure that the model is a sufficiently accurate representation of the system. The primary response for the simulation, ARENA output packet half width. The responses obtained showed a range that was wide enough to encompass the variation found in the system, while being sufficiently accurate [8]. The primary metrics used for the validation is the half width confidence interval matching.

VII. SYSTEM RELIABILITY

System reliability is measured in MTTF (Mean time to Failure) or FITS (Failure in Time). The MTTF is the mean value of life distribution for the population of devices under operation or the expected lifetime of an individual device. MTTF is measured in hours. The FITS is the measure of failure rate in 10^9 device hours.

If $MTTF_{Disk}$ and $FITS_{Disk}$ is the MTTF and FITS of a single disk device, and $MTTF_{JBOD}$ and $FITS_{JBOD}$ is the measurement of a JBOD system with n disk, the resulting failure rate parameter is shown in equations 1 to equation 3:

$$FITS_{Disk} = \frac{10^9}{MTTF_{Disk}} \tag{1}$$

$$FITS_{JBOD} = n \times FITS_{Disk} = \frac{n \times 10^9}{MTTF_{Disk}} \tag{2}$$

$$MTTF_{JBOD} = \frac{10^9}{FITS_{JBOD}} = \frac{MTTF_{Disk}}{n} \tag{3}$$

With the current typical Fibre Channel disk drive MTTF parameter of 1.5×10^6 hours, a JBOD with 90 disk drives has a MTTF of 16,666.7 hours, or 1.9 yrs. This shows that with the use of the JBOD technology, the raw MTTF number is clear too low for the application that demands high reliability. The latter analysis shows that the RAID technology increases the MTTF of disk array systems.

In RAID Reliability Solution, illustrating the reliability that RAID system technique provides, the following terms are defined:

- n = total number of disk with data
- g = number of datablock in a group
- c = number of checksum block in a group
- $m = \frac{n}{g}$ = number of groups
- $MTTR_{Disk}$ = Mean time to repair a failed disk
- $MTTF_{Disk}$ = Mean time to failure

Assuming that the disk failures are independent and occur at a uniform rate, then equation 4.5 gives the mean time to failure of the RAID system

$$MTTF_{Group} = \frac{MTTF_{Disk}}{(g+c)} \times \frac{MTTF_{Disk}}{((g+c-1) \times MTTR_{Disk})} \tag{4}$$

$$MTTF_{Group} = \frac{(MTTF_{Disk})^2}{(MTTR_{Disk} \times (g+c-1) \times (g+c))} \tag{5}$$

$$MTTF_{RAID} = \frac{MTTF_{Group}}{m} \tag{6}$$

$$MTTF_{RAID} = \frac{MTTF_{Disk}^2 \times g}{(MTTR_{Disk} \times (g+c-1) \times (g+c) \times n)} \tag{7}$$

Calculating the improvement on reliability by using the RAID system associated with 90 data disks divided into groups 6 groups with each having 15 disks. 6 additional disk are provided which are required for the checksum (total number of disk = 96; $n= 90$; $g= 15$; $c = 1$). Assuming that it takes 10 hours to repair a failed disk (replace the faulty disk and repopulate the data based on the checksum $MTTR = 10$ hours) and a normal disk mean time to failure of 1.5×10^6 hours ($MTTF_{Disk} = 1.5 \times 10^6$ hours).

$$MTTF_{RAID} = \frac{(1.5 \times 10^6)^2 \times 15}{10 \times 15 \times 16 \times 90} = 1.56 \times 10^8 \text{ hours} = 17,836.8 \text{ yrs}$$

Comparing the result of the MTTF for the 90 disk JBOD system (only 1.9 yrs.), it is clear that the RAID 5 technology used in this SAN design has a high increase in reliability of the storage array of over 10 thousand years therefore has established itself to be of high reliable storage array systems.

VIII. CONCLUSION

The network based on core/edge topology is symmetrical; every device has an equivalent path to other devices connected in the network. One problem of the Core/Edge topology is that when one of the Inter-Switch-Link (ISL) fails, the network becomes asymmetrical. Therefore, in this design, there are two paths for each host-device pair to retain its symmetric nature should an ISL fails. Comparing the result of the MTTF for the 90 disk JBOD system (only 1.9 yrs.), it is clear that the RAID 5 technology used in this SAN design has a high increase in reliability of the storage array of over 10 thousand years therefore has established itself to be of high reliable storage array systems.

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REFERENCES

- [1] H. Dot, "Using Fibre Channel to Reduce SCSI Storage Costs" Systems Corporation, 6305 El Camino Real, Carlsbad, California 92009, USA. pp. 1 -6, 2004.
- [2] G. Gregory, "High Speed Total Order for SAN infrastructure" Institute of Computer Science, The Hebrew University of Jerusalem, Israel. pp. 13-26, 2005.
- [3] T. Jon, L. Fabiano, and M. Richard, "Introduction to Storage Area Networks" IBM RedBooks, pp.23 -45,2006.
- [4] W.D.Kelton, R.P.Sadowski, D.A.Sadowski, "Simulation with Arena" Second Edition, McGrawHil. pp. 2 -100, 2001.
- [5] D.T. Timothy, "Optimal Core-Edge Storage Area Network Design" Department of Engineering Science University of Auckland, New Zealand. pp. 1 – 10, 2005.
- [6] H.Xiangdong, "Design and Implementation of Fibre Channel Switch on Linux" University of New Hampshire, September. pp. 1 -80, 2000.
- [7] B.Martha, B.Nick, F. Jim, H. Robert, I. Richard and T. Hoot, "Functionality and Performance Evaluation of File Systems for Storage Area Networks (SAN)", pp. 1 -19, 2005.
- [8] A. N.Uwaechia, D. D.Dajab, B. A. Adegboye "Performance Modelling of Ahmadu Bello University Data Network using a Storage Area Network SAN Design Concept" International Journal of Computer Application, Vol. 63 No. 10. pp. 6 -13

BIOGRAPHY



Anthony Ngozichukwuka Uwaechia has been serving as asite Engineer in Lilleker Bros. Nig. Ltd., where he gained experience in the field. He joined the Ahmadu Bello University, Zaria as a postgraduate research student 2009/2010and Majored in the area of communication Engineering. The author in the course of his research served as a mentor to his fellow colleagues, he gained a Postgraduate Scholarship Award from the Nigeria –Sao Tome & Principe Joint Development Authority. Author just currently gained admission to study to the level of a CCIE in Zoom Tech., Hyderabad, India immediately after which to enroll for a PhD.



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