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ENHANCING AVAILABILITY OF GOVERNMENT DATA CENTER SYSTEM (GIDC NEPAL)

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Abstract— In this modern technological age, the world is moving towards online electronic system that makes people convenient and fast to access services online. The GIDC (Government Integrated Data Center) plays vital role in providing e-government services to the public. The transformation from manual system to the online system of government services has been increasing. The purpose of this research is to enhance availability of GIDC system so that a single point of failure cannot affect the e-government services. E-government service might be unavailable or disturbed due to unexpected events such as hardware failure, network connection disruption, corrupted database, natural disaster such as earthquake, fire, flood, etc. in the GIDC. We cannot stop natural disaster but we can minimize the damage. We can also improve availability of GIDC system during natural disaster by changing the design of GIDC system architecture. So, the purpose of this study is also to enhance availability of GIDC system of Nepal even if natural disaster occurs.

Keywords— Enhancing Availability, Government Data Center System, GIDC Nepal

I. INTRODUCTION

In this technological age, government as well as private organizations are moving towards online system that makes people convenient and fast to access services online. In 2000, National Information Technology Center (NITC) was established in Nepal which has Government Integrated Data Center (GIDC) that provides many services to government agencies such as domain registration, web hosting, email services, etc. [1] On September 2015, NITC, Department of Land Reform and Management (DOLRM) and Inland Revenue Department (IRD) signed Service Level Agreement (SLA) for LRIMS (Land Records Information Management System) application management. [1] On the same day, SLA for Public Service Recruitment Management System (PSRMS) application management were done between NITC and Public Service Commission (PSC). [1] A data center is a centralized location for management, storage, collaboration, processing and exchange of data within an enterprise. Data centers play crucial role in maintaining and providing high availability of online systems.

High availability is a system design that ensures a high level of operational continuity over a given period of time. The goal of high availability is to provide continuous service to the users with minimum downtime. With high availability system design, continuous service can be provided to the users with minimum downtime even if unexpected events occur.

Government Integrated Data Center (GIDC) plays important role in providing shared infrastructure to government agencies and in rendering e-government services to the public. Nepal GIDC provides shared infrastructure for many government agencies. There is an increase in using Nepal GIDC infrastructure by government agencies. 1070 government domains have been registered, 532 government websites have been hosted and 102 government agencies use email service from the data center. [1] After the devastating April 25, 2015 earthquake of Nepal, some government agencies have relocated their servers and web sites to the data center. GIDC should protect government and public data. It should have disaster recovery plan. Research should always be done regarding changing and growing technology so that the availability of the online service can be made better by using better technology.

Many technologies are used in data center such as clustering, load balancing, virtualization, Storage Area Network (SAN), Network Attached Storage (NAS), etc. A server cluster is a group of independent servers working together as a single system to provide high availability of services for clients. Load Balancing is the ability of a system to distribute and share resources such as memory, processor, etc. across the cluster. Storage Area Network (SAN) file systems are based on RAID controllers or hard disks that communicate via a fibre channel or from a network which can be accessed from any connected host to any connected disks. [2] Network Attached Storage (NAS) is a shared storage that contains one or more hard disks connected to the network which is accessible from any of the users or servers.

II. PROBLEM STATEMENT

The transformation from manual system to online system has been increasing in Nepal. GIDC online services can be disturbed or unavailable due to unexpected events such as network connection disruption, hardware failure, corrupted database, short circuit, device collision, natural disaster such as earthquake, flood, fire, etc. Nepal is vulnerable with regard to natural disaster due to geographical location especially earthquake. [3] Earthquake as well as electricity might also trigger fire from collision. So, there is possibility of disturbance in high availability of e-government service to the citizens if there is infrastructure failure in the system.

III. OBJECTIVE

The main objective of this research is to enhance availability and reduce downtime of GIDC online system of Nepal.

IV. LITERATURE REVIEW

Availability level continue to rise as business rely on IT services. In 1996, there were $4.54 billion loss in American companies due to system downtime according to IBM study from the nineties reports. [4] In the same way, the availability of e-government services affect whole country. Nepal is one of the most vulnerable countries in the world in terms of earthquake hazard. A devastating earthquake of 7.6 Mw struck on April 25, 2015 at 11:56 local time in Gorkha, Nepal which affected whole country. [5] This implies that there is possibility of damage of system infrastructure in e-government system in the country at any time.

Many technologies can be used in data center for enhancing the availability of the system. Load balancing is useful in data center applications for handling traffic efficiently across a set of servers. [6] Server clusters are used for applications that have changing data frequently. For example, file servers, print servers, database servers, etc. can use server clusters. [7] HAS (Highly Available and Scalable Cluster) architecture improves availability by using redundancy models, load balancing that prevents single point of failure. [8]

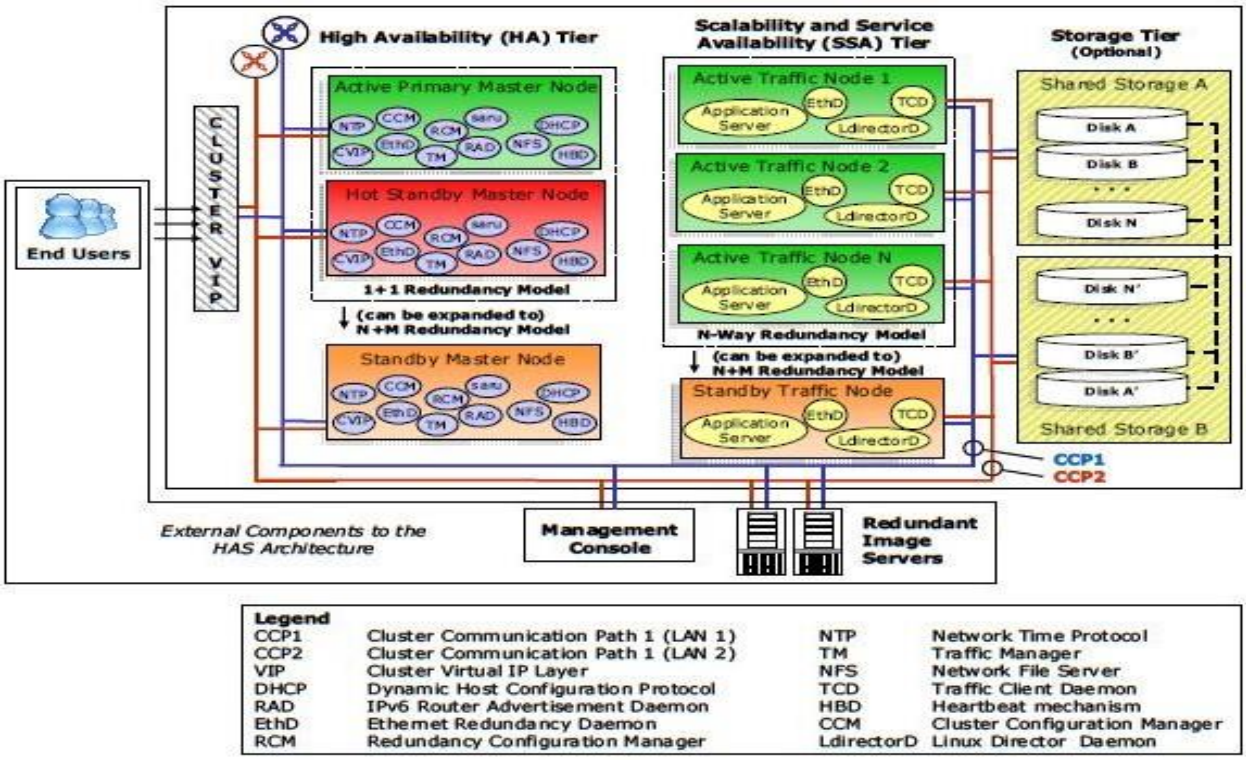

Figure 1: The HAS Architecture [8]

Enterprise data center architecture has no single point of failure with redundant components and redundant data centers. [9]

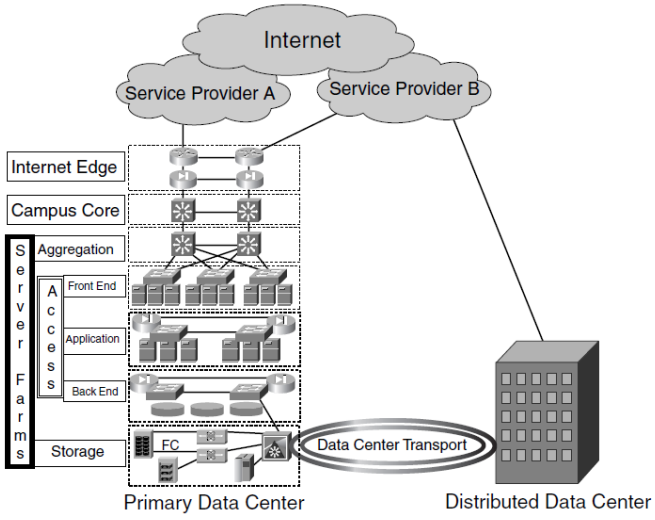

Figure 2: Topology of an Enterprise Data Center Architecture [9]

Nowadays, server virtualization has been used in data centers. Better performance can be achieved by applications in data centers by dividing functional components such as web servers, databases in different VMs to provide HTTP requests. [10] Virtual machine migration is easy across groups of data centers within LAN as well as WAN even with low bandwidth. [11]

Data storage is essential part of data center architecture for applications storage requirements. The most common storage technologies are Direct-Attached Storage (DAS), Network-Attached Storage (NAS) and Storage Area Networks (SAN). Appropriate data storage technologies should be selected based on the requirements for solution. SAN and NAS are used in large scale data center. [12] SAN is used for data availability, disk utilization, disaster recovery and data backup. SAN can be used for mirroring the data to another disk located in different geographical location. [13] NAS stores files and data over the network and makes them available in the network. NAS uses the TCP/IP protocol for sending and receiving the data over the network. [13]

Software aging occurs in all types of software, however it can be slowed down and it is sometimes possible to reverse the effects. The errors of software aging can be corrected by software rejuvenation with limited fix to the problem. [14]

The total availability of a system can be calculated based on the probability to happen and different failure scenarios. To obtain more accurate result depends on going into more detailed calculations which can be more complex and time consuming. [15] Mean Time Between Failure (MTBF) is a basic measure of a system's reliability. It is typically represented in units of hours. Higher MTBF represents higher reliability of the product. Mean Time To Repair (MTTR) is the expected time to recover a system from a failure. As the MTBF goes up, availability goes up. As the MTTR goes up, availability goes down. [16]

Markov modeling is used for analyzing complex systems such as system architectures. Markov models provide various other measures of a system, including availability, MTBF, MTTR, the probability of being in a given state at a given time. [16]

A system with monitoring and analysis is useful for performance troubleshooting and monitoring application interference. Troubleshooting tools can be used for detecting problems and alert system administrators for potential solutions which can reduce system downtime in large-scale distributed systems. [17]

V. METHODOLOGY

This research is based on case study of GIDC of National Information Technology Center (NITC) in Nepal. Both qualitative and quantitative approaches were used for data analysis. Qualitative analysis were used for non-numerical data from case study to identify such as whether the data center has monitoring and analysis system. Quantitative analysis were used for numerical data such as number of websites hosted, number of domains registered, etc. Markov model has been used for analyzing the system.

VI. RESULT AND DISCUSSION

The services and activities that GIDC provides are

Table 1
GIDC Services and Activities [1]

Services and Activities	Total
Domain Registration	1070
Web Hosting	532
Email Service	102
Internet Service	54
Employee Trained	2400
Gate Pass System	47
Development	4

Based on the case study done on Nepal's GIDC system, the current GIDC server system architecture has been identified. The current network systems have redundancy such as WAN failover, redundant switches, redundant routers, etc. The server architecture of current GIDC system has client-server architecture with Presentation, Application and Data Management in each individual server. Data is backed up in NAS (Network Attached Storage) automatically. Keeping Presentation, Application and Data Management in a single server reduces performance of the server as the server has to do more processing. The current GIDC server system does not have server configured in parallel so that if one server is unavailable, the other continues to serve the requests. The current server configuration does not provide failover to another server if one server goes down. In the current server system, if a server goes down, the clients cannot get service. So, the current server system should be changed in order to enhance availability of the system.

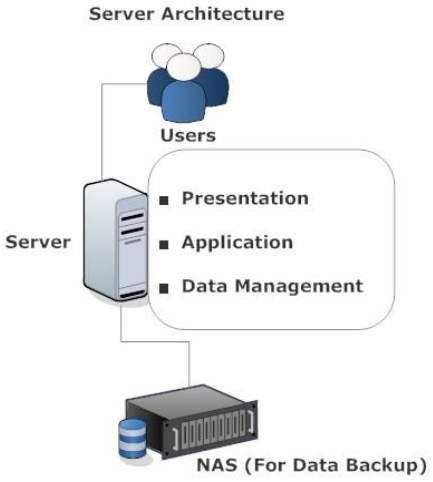

Figure 3: Current Server System Architecture

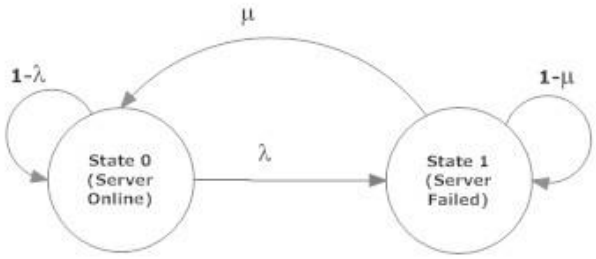

Figure 4: Markov Transition Diagram for Current Server

The probability can be calculated at each state of the Markov transition diagram (Figure 4).

Figure 4 represents the Markov transition diagram for current web server/database server. In the above Markov transition diagram, State 0 represents (Server Online) and State 1 represents (Server Failed). λ represents failure rate and μ represents repair rate. The transition matrix for the above transition diagram is given below:

	State 0	State 1	
State 0	$\begin{bmatrix} 1-\lambda & \lambda \\ \mu & 1-\mu \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$		
State 1			

Table 2
Current Server Availability

System	Redundancy	Availability	Unavailability
Current Server	1	$\frac{\lambda}{\lambda+\mu}$	$\frac{\mu}{\lambda+\mu}$

The above table shows the availability of the current server system.

Monitoring and alert system is essential in data center to improve availability. Automated monitoring of networks, web sites, services, applications, etc. for any faults or failures and informing system administrators via email and SMS can reduce downtime of system. The GIDC has the network monitoring system in which system administrators are informed via email when any problem occurs in the networking system. However, it does not have monitoring system for applications such as web sites availability, web sites performance monitoring, etc.

In order to enhance the availability of data center, four system architectures have been developed and proposed.

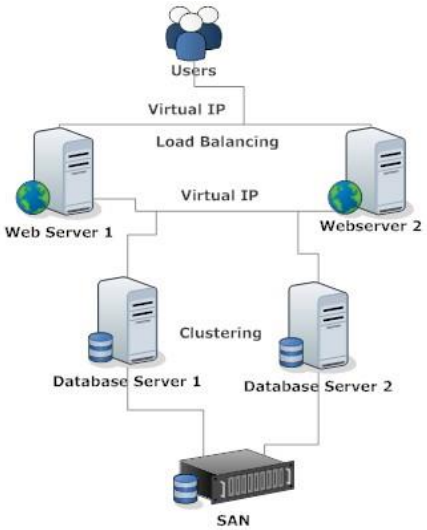

Figure 5: Proposed System Architecture 1

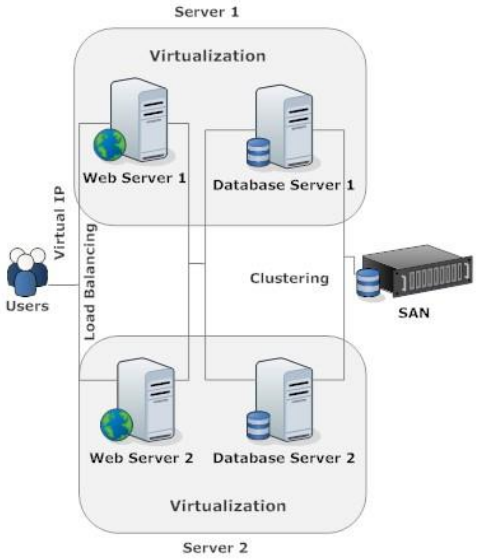

Figure 6: Proposed System Architecture 2

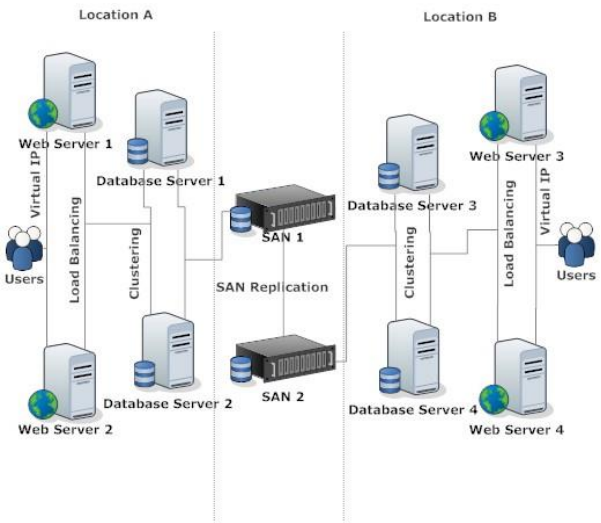

Figure 7: Proposed System Architecture 3

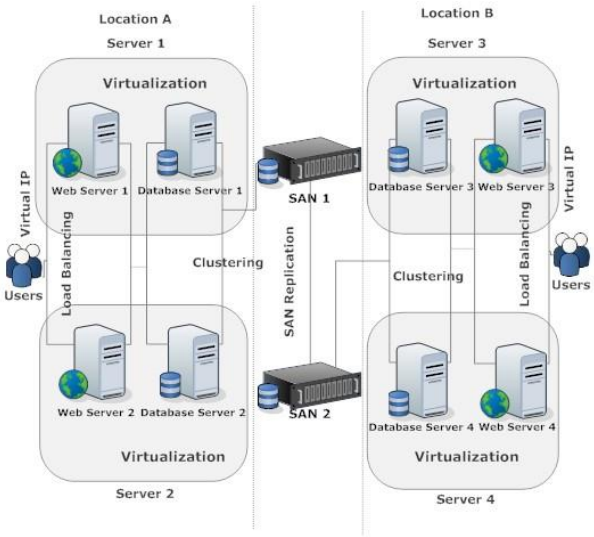

Figure 8: Proposed System Architecture 4

Table 3
Architecture Comparison

Fig	Virtualization	No. of Physical Servers	Suitable Conditions
1	No	4	When server has less resources. Failover within single geographical location.
2	Yes	2	When server has more resources. Failover within single geographical location.
3	No	8	When server has less resources. Failover in different geographical locations.
4	Yes	4	When server has more resources. Failover in different geographical locations.

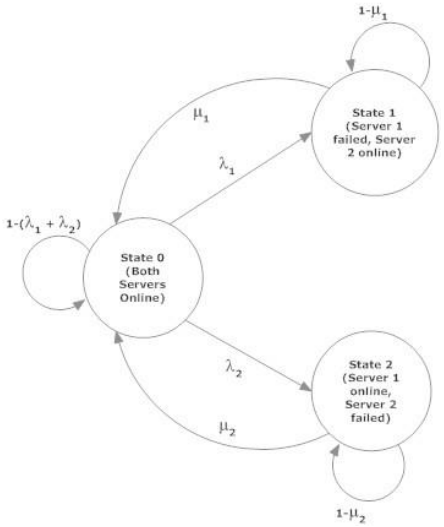

Figure 9: Markov Transition Diagram for Proposed Server System

The transition matrix for the above transition diagram is given below:

	State 0	State 1	State 2	
State 0	$1-(\lambda_1+\lambda_2)$	λ_1	λ_2	$=\begin{bmatrix}1\\1\\1\end{bmatrix}$
State 1	μ_1	$1-\mu_1$	0	
State 2	μ_2	0	$1-\mu_2$	

Table 4
Availability Comparison

System	Redundancy	Availability	Unavailability
Current Server	1	$\frac{\lambda}{\lambda+\mu}$	$\frac{\mu}{\lambda+\mu}$
Proposed Server System	2	$\frac{2\lambda}{2\lambda+\mu}$	$\frac{\mu}{2\lambda+\mu}$

Configuring each component parallel in a system increases availability of a system. Replicating data between different geographical locations enhances availability of system even if natural disaster occurs.

The above availability is the availability of sub system web server/database server only. The availability of each sub system such as Storage Area Network (SAN), Network Attached Storage (NAS), router, switches, etc. should be calculated and then total availability of system should be calculated. The availability should be calculated periodically such as annually. Comparison should be made between previous and present availability. If the present availability decreases, the reason why the availability has diminished should be analyzed and appropriate actions should be taken in order to enhance the availability.

VII. CONCLUSIONS

GIDC Nepal provides services to many government agencies and performs many activities such as domain registration, website hosting, email service, internet service, gate pass system, training, etc. It is crucial to enhance availability of data center system due to the GIDC acting as the central nervous system of the country and Nepal being vulnerable to natural disaster especially earthquake. The GIDC should calculate availability of each component and system periodically such as annually so that it helps to know the current availability of the system and makes easier for prediction in order to enhance availability for the future. The data and system should also be kept in at least one different geographical location from the current GIDC so that e-government services can still be accessible even if one location has suffered from unexpected events such as fire, water, earthquake, etc. Automatic alert system should be used in GIDC to inform system administrator via email/SMS about failure or problem in websites, application or system so that it can help reduce downtime.

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