A Proposal for using of Synchronous Database Replication System on Unstable Networks

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E-Learning system is primarily applicable for developing countries that do not have a good ICT environment. It gives many educational resources through Internet to learners. However, to keep service uninterrupted, it requires stable network environment. For rural areas, stable community wireless networks can be considered a good alternative. However, its infrastructure imposes severe challenges in such areas mainly because of infrastructure related problems such as frequent disruption of electricity supply and other hardware related problems. In this paper, we propose an adaptive e-Learning system, which is primarily applicable for developing countries that do not have a good ICT environment. Our approach do not requires stable network to keep stable e-learning environment. We apply database replication techniques in order to achieve better services for unstable networks. Proposed system will have the feasibility, effectiveness, and reliability to overcome such network instability. It also helps to reduce digital divide in such deprived areas.

1. Introduction

In the 21st century, education has been widely accepted as a basic need for every citizen. It is referred to as the backbone to the development of any nation and a key factor towards developing a global community. Education systems in the developed countries have benefited significantly through the advancement of technology. Whereas, the developing countries still lack a proper learning system in the school and colleges. Schools in the remote areas of most developing countries still do not have access to the latest technologies, depriving students of opportunity to quality education.

Recently, there has been an emphasis on developing community wireless mesh networks, specifically, for rural areas in order to connect them with the other regions in the world. The flexibility and scalability inherent to the wireless mesh networks provide solutions to bridging the digital divide and connecting remote communities in the world[1]. However, the proper functioning and reliability of such effort is poor due to the lack of supporting infrastructure.

Most of the communication networks in the developing countries suffer from severe instability. For instance, frequent and prolonged electricity disruption, bandwidth limitation, lack of redundant network links, limited number of active local network administrators, lack of proper safety measures against natural disasters (e.g., thunder, lightning, earthquakes etc.) are some major causes of instability of those networks.

On the other hand, e-learning system is a good solution for education of rural area. Existing environment of schools in rural area have a big problem of educational resources (i.e. materials, teachers and infrastructures). E-learning gives more educational resources through Internet easily. However, to keep stability in services, it requires stable network environment. As mentioned above, most of the communication networks in the developing countries suffer from severe instability. In order to achieve the maximum benefit of e-learning system, the stabilization of the network environment or the overcoming of instability is required.

In this research, we intend to provide a sustainable e-learning environment in such rural areas. Sustainability in terms of serviceability can be achieved by providing workable system which can operate during offline. In order to achieve this objective, we focus on to develop a collaborative e-learning system which uses synchronous database replication technology in order to share information among the schools in the targeted area. We adopted the Moodle which is one of popular e-learning system, and develops an interface to synchronize databases which is working under Moodle of each school.

In this paper, we propose a synchronous database replication system for supporting an adaptive e-Learning system on unstable networks. A structure of synchronous databases which is working under Moodle of each school was shown.

2. Target Area

2.1 Community Wireless Network of Kaski Nepal

Most of the previous work establishing the community wireless network (CWN) has focused in the remote areas at high altitude in the mountainous region of Nepal. In a prior work, Paudel[2] and Shrestha[3] built a CWN connecting two remote villages, Dhital and Kaskikot, which are located near Pokhara. Pokhara is one of the biggest cities in the Kaski district and is located approximately 15km air distance from Dhital and Kaskikot, as illustrated in Figure 1. We have a server station in

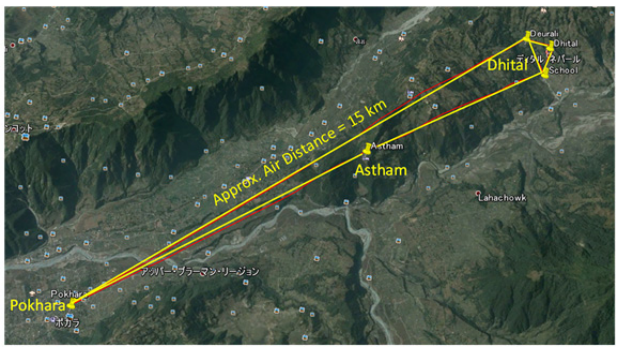

Figure 1 Current Geographical Location of CWN

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Pokhara where the main internet server is located having direct connection with local internet service provider. Our targeted schools are also located in both Dhital and Kaskikot. These schools are connected to the internet through CWN. The first CWN in this target area was established in 2011, and we had built new node at Astham at winter in 2014. In our other works, we intend to improve the performance of the existing CWN by implementing a supplementary redundancy for increasing network stability.

2.2 Existing Network Topology and Field Scenario

Figure 2 illustrates the current network topology in Kaski district. This network infrastructure has five nodes. The main station or node-A is located in the main city Pokhara which is linked up with the local internet service provider (ISP). This node is the primary server station of this infrastructure. Node-A further distributes internet into node-B and node-C. Node-B is a newly constructed relay tower at Astham. Node-C is a redundant node located at Deurali, near Dhital. Final node-D and node-E illustrate the target schools of this research. From a configuration perspective, this is a partial mesh network.

2.3 Current Network Issues

The existing network implemented in Kaski district of Nepal is not stable. Such instability makes it difficult to establish robust network infrastructure and a sustainable e-learning system. Some major network related problems are listed as follows:

(1) Frequent and prolonged electricity disruption: Unreliable electricity transmission is one of the major problems facing the developing countries. The targeted research infrastructure is also severely affected by this problem.

(2) Lack of Redundant Nodes: Redundancy implies that a service should continue the system failure thereby providing an additional system as a backup[4]. Lack of proper backup servers, electric power supply, additional traffic links are critical factors causing the instability of the CWN.

(3) Limitation in Bandwidth: Due to financial constraints, the CWN still lacks access to the high-speed internet service.

(4) Natural Disasters: Natural phenomenon affects a lot in such open infrastructure. Thunder, lightning, and earthquakes are some major reasons behind instability. Figure 3 illustrates the damage caused by natural disaster (in this case lightning) at Deurali node in summer of 2014. The left figure is a picture shot immediately after setting.

(5) Geographical Difficulties: The network infrastructure is located in the high altitude, mountainous terrain in the Himalayan region in Nepal, where geographical conditions are extremely difficult for establishing efficient transportation network, which seems to hinder the progress of all other facilities including the business expansion of internet service providers in such areas.

(6) Security Measures: To the best of our knowledge, there is hardly any research conducted to study the security measures for CWN.

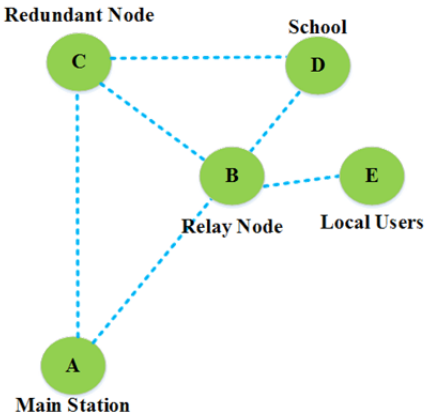

Figure 2 Current Network Topology

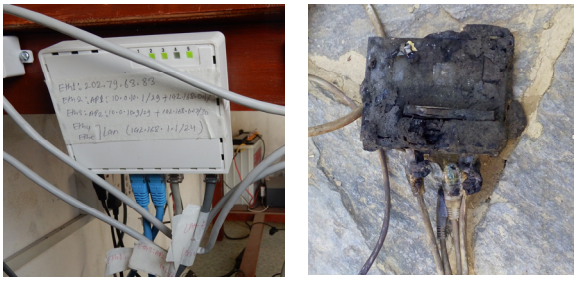

Figure 3 Damage caused by Lightning at Deurali

3. Database Replication

3.1 Introduction

Replication is a process normally used to distribute and backup the system information in order to increase the availability, improve reliability, and make a system highly accessible[5]. In replication multiple instances of the same data is stored in multiple redundant devices, which may be located in the same location or distributed in the several locations. It is one of the key mechanisms to back up the system information in to multiple devices. We can further say that it increases the availability of data in distributed system[6].

Shrestha et al.[3] have proposed the method of database replication system in order to establish sustainable e-learning system. The system was especially designed for unstable network of CWN Nepal. This method is an integration of database and content sharing applications and very affective on this network. The proposed system architecture and its working principle are discussed in the following sections respectively.

3.2 Existing System Architecture

Figure 4 represents the overview of existing system architecture on CWN. According to this architecture, there are three different zones, Zone A, Zone B and Zone C. Each zone consist at least one school and each of them have a database servers. Herein, we define a database server as combined set of standalone MySQL server (SMS) and Galera Cluster Node servers (GCN). GCN works as master server to each other and based on the synchronous replication method. It replicated the database in between two different Zones. SMS is a local server.

Users can upload their information through SMS server and it synchronizes the database with GCN when the synchronization command executes.

3.3 Working Principle

From figure 5, the working principle of this existing system is described. There are three nodes and each node consists of school with the set of servers that is GCN and SMS. We will perform master slave replication between GCN and MySQL server. In this research, each node is assumed as a school. Each school has given an authentication to access the database system. When the information need to be shared to the require nodes then the system will be delivered to all available nodes. The data will not be sent to the down node. But when down network gets alive, the system automatically sense the availability of the network and the data will be delivered to this node also. That means the data will be delivered to all active nodes even if there exist a failed nodes. The green line represents that the link or node is alive and the data will be delivered to all active node. The dotted red line is the downtime of the node when the power is cut off. During this down time, data will be stored as it is in the same server and will be delivered when network is alive. In this way the data synchronization is occurred in this proposed system.

3.4 Problems of Existing System

There are some limitations in the existing system[3]. The system managed some schedule time for database synchronization. It will be very effective if the system is capable of sensing the availability of network itself and start the synchronization process automatically without scheduled time. Furthermore, there was no discussion on any security issues. There are still lack of algorithms to increase the reliability of database and content sharing in order to acknowledge whether the synchronization process has taken place successfully or not. We will focus our attention to address these shortcomings seamlessly in our next future work. Furthermore, the system proposed by Shrestha[3] has not produced workable result that can benefit the local school. There is a requirement to build upon working system.

Moreover, until now, we did not consider any concrete application for using our database replication system. We should survey and choose some suitable e-learning system. And we should integrate its e-learning system to our system in order to synchronize the data.

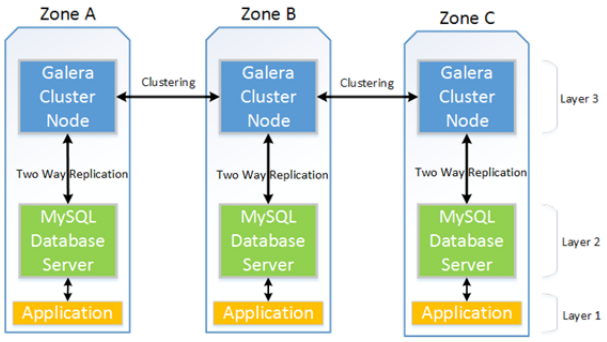

Figure 4 Existing System Architecture

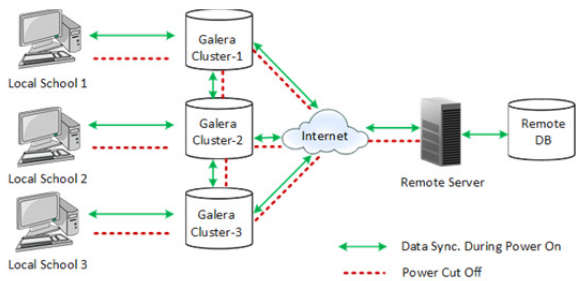

Figure 5 Basic Working Principle

4. Newly Proposed System

4.1 System Outline

We have done the preliminary study and analyzed the existing system architecture. We believe that this system is one of the best methods for sharing information between school of CWN networks of Nepal for implementing the sustainable e-learning system on unstable environment. But there are some limitations in the system for which we are going to upgrade and enhance in our newly proposed system.

Our newly proposed system will focus on the concept of data sharing between the schools of rural areas to implement a collaborative learning environment. It will provide group communication platform in which students of different schools are able to share and discuss their opinion on different subjects. They can also able to view and comment each other activities. It helps them to understand other school activities and analyze their own performance. Such system will increase their self-learning capacity and built their self-confidence also.

The target network infrastructure is distributed in CWN networks of Nepal. Figure 6 shows our newly proposed system block diagram. From this diagram, we assume there are three schools in our newly proposed system. These schools are connected to internet through CWN. Two of them are located in Nepal and remaining one is in Japan. The main purpose of assuming the school in Japan is to remotely control and manages

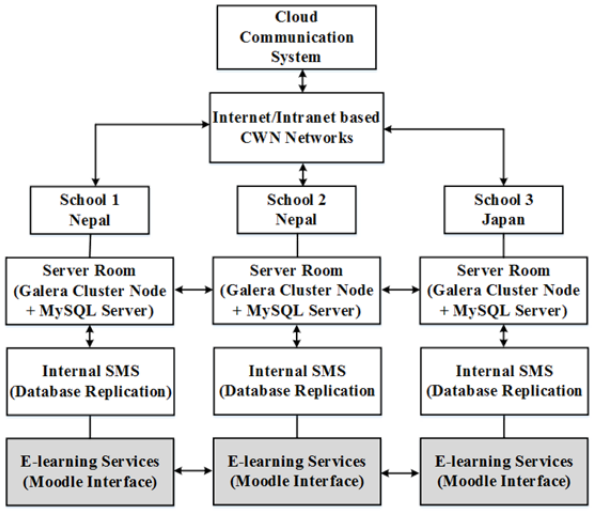

Figure 6 Proposed System Block Diagram

the local schools of Nepal. Each school has a server room with GCN and SMS. Each server is configured and is capable of database replication techniques in order to share the data among the schools.

Furthermore, we adopted "Moodle" to concrete e-learning application for integrating with our database replication system. Moodle is one of the latest and famous open sources learning management system (LMS) that has been widely used in education system. We found some other learning systems, but we choose Moodle because it uses MySQL as its backup engine and our system is also based on MySQL and its functions. We have to properly configure the synchronization process between MySQL and Moodle. So this will be one of the challenging tasks in this research.

We will facilitate the user able to create their login accounts and access the interface of e-learning system in order to fulfil their requirements. We will also build the services like voice and video so that they can also share their voice and video messages. On the other hand, the system is not only applicable for schools and colleges. This system further can be used for some other purposes like online business, tourism, marketing, online medical treatments etc. by the local communities.

4.2 About Moodle

Moodle is an open source LMS. It is written in PHP and based on MySQL as its database engine. It is one of the best evolving LMSs which is mostly used in educational sectors to create collaborative learning environment. It consists very flexible applications allowing Moodle users to fulfil their requirements. It has some features that allows administrators to establish a communication between server site and client site.

4.3 Preparation Experiments

In order to understand and enhance the existing system, we have done some lab experiments by using the algorithm developed in the previous research[3]. In this lab experiment, we have created two different networks which is illustrated in figure 7 and figure 8. In this scenario, we can say each network is a LAN. We assume each network has school and each of them consist of database server. The database server is a combination of both GCNs and SMS. We configured each database server and are capable of sharing information.

In addition, we tried to replicate database and its contents (e.g., table) from one end to another. We create database named db_name and insert some information in tables (e.g., tbl_db). Then we execution replication command form the client PC-1. The database and table was successfully replicated to the other client end. That means, user from client PC-2 was able to view and edit the information sent by client PC-1.

After conducting these experiments, we can conclude that, database replication has been successfully accomplished between two different servers. Table 1 illustrates the database name (e.g., db_name) and table name (e.g., tbl_db) that we created and synchronized between the schools of two different networks.

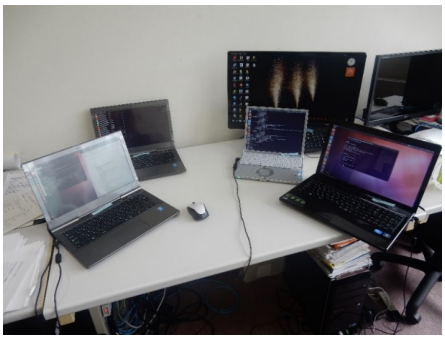

Figure 7 Experiment Setup

Figure 8 Creating Two Different LAN

Table 1 Database Synchronization and Content Sharing

Local Area Network A				Local Area Network B			
School A				School B			
Database Synchronization Activities				Database Synchronization Activities			
Create Database	Create Table	Show Database	Show Tables	Create Database	Create Table	Show Database	Show Tables
db_name	tbl_db					db_name	tbl_db
		db_name	tbl_db	db_name	tbl_db		

5. Some other Related Research on E-learning

There are hardly limited number of research has been done on the Himalayan region of Nepal although lots of researches on e-learning system are doing at the same time all over the world. Some research that has been done on e-learning education systems are described below.

Shweta S. and Katkar M. D.[7] discussed advantages of using of virtual e-learning system for those students who wants to continue their education from e-learning programs.

Essaid El. B. et al.[8] suggested some new teaching strategies on e-learning system that matches learner's personality using Myers-Briggs Type Indicator tools. This is a kind of virtual learning modules for personality recognition and selecting an appropriate teaching strategy.

Tubaishat A. and Lansari A.[9] discussed about an effect of e-learning system for students of Gulf region. They conclude that, e-learning has improved student's technical skills and self-confidence in taking charge of their learning.

By doing the review of above research papers, we can say that e-learning is an essential sector in education. Although, the purpose of all these research is for developing better education platform to enhance the quality of education and provide services for those students who wants to continue their studies

form online methodology. Most of these researches are focused on end user interface only. We found hardly the issues regarding the network infrastructure. All these research were done in the stable network infrastructure.

In this paper, we will focus our research on establishing collaborative e-learning system especially on unstable network environment of developing countries. We will discuss about the back-end mechanism of the system. The back-end implies the meaning of inner mechanism of the system. In details, we discuss about the back-end supporting mechanism to support the sustainable e-learning system. We discuss on integrating of database replication method and Moodle e-learning education management system. This is one of the best methodologies for establishing highly available e-learning environment.

6. Future Works

We have discussed about an efficient method for database replication developed by previous research[3]. This is one of the best methods for establishing highly available e-learning system in unstable environment. Despite of this fact, there are still some weak points or limitations that we want to figure out for our further research experiments.

In our future work, we will seamlessly sort out the limitations of previous methodology. We will focus our research on the following points. (i) By using our interface, students and teachers will be able to modify the updated information immediately when there is network connection. (ii) Students will be able to access e-learning system whenever there is power supply regardless of network connectivity. (iii) We will develop a system capable of automatic synchronization immediately when it sense the availability of the network not at scheduled time set by the user. Furthermore, (iv) We will develop a system package by integrating the database of Moodle and MySQL servers to synchronize database.

This system platform can further be used in multipurpose applications if applied in the right contextual. Figure 6 shows the future image for applying our system to other services. Online businesses, marketing services of local products, online medical counselling, and tourism developments are some major examples.

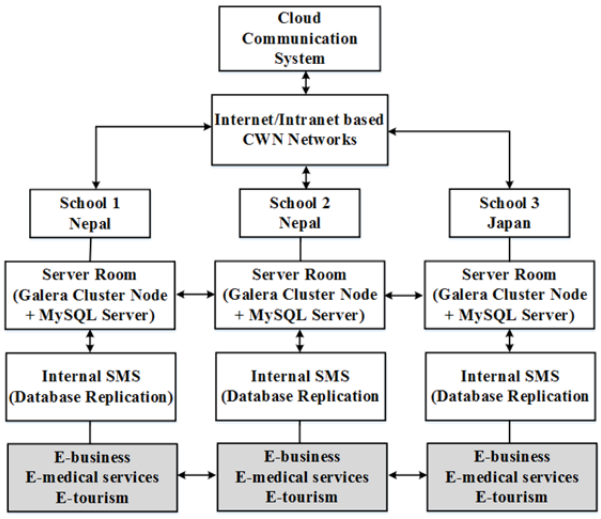

Figure 9 Future Image for Applying Other Services

Beside this, there are still some more research dimensions to be accomplished in order to establish highly adaptable and highly available e-learning system. We will point out some of them below:

(1) Finding the existing network problems.
(2) Remote controlling and management of the system.
(3) Making the system capable off file sharing between remote servers (e.g. video, voice, pdf etc.).
(4) Development of algorithms for fast failure recovery.
(5) Confidence development of students by making independent learning environment.
(6) Establishing of collaborative learning system.
(7) Introduction of virtual learning environments.
(8) Security measures.
(9)Making the system more user friendly (for e.g., multi-language interface system, like English, Japanese, Nepali etc.).

7. Conclusions

Recently, in schools and colleges of developing countries, it has been an emphasis on developing e-learning services. It is referred to as the backbone to the development for these countries. Schools in the remote areas of most developing countries still do not have access to the latest technologies, depriving students of opportunity to quality education. These school are lack of enough resources like educational materials, teachers. Additionally, most of the communication network infrastructures of these countries are unstable. Frequent and prolonged electricity disruption, bandwidth limitation, lack of redundant network links, limited number of active local network administrators, lack of proper safety measures against natural disasters (e.g., thunder, lightning, earthquakes etc.) are some major causes of instability of those networks.

In this research, a collaborative e-learning system in those unstable environments was proposed. To keep stability in services, it requires stable network environment. As mentioned above, most of the communication networks in the developing countries suffer from severe instability. In order to achieve the maximum benefit of e-learning system, the stabilization of the network environment or the overcoming of instability is required. We focus on developing a collaborative e-learning system which uses synchronous database replication technology in order to share information among the schools in the targeted area. We adopted the Moodle which is one of popular e-learning system, and develops an interface to synchronize databases which is working under Moodle of each school.

Furthermore, some practical experiments on database replication system were done, and some data among two different servers were successfully shared. In this experiment, each server is assumed as a school. We aim to upgrade and enhance the existing system by integrating database of Moodle LMS with MySQL database in order provide stable learning

system in the schools distributed in the CWN of Nepal. The system will be beneficial for the students of those schools. We will further establish a communication interface to link the schools of Nepal and Japan in order to remotely manage and control the local servers of Nepal.

In addition, the proposed system can be applied widely to other services, not only for education. For example, business, commerce, and medical are good application field. After our proposed system developed, we aim to apply it for other services.

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