International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 88-90, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1001

Development of a Web-Based Research and Community Service Information System to Improve Higher Education Services

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Abstract: Currently, the Institute for Research and Community Service (LPPM), Universitas Negeri Medan (UNIMED), tried to continue developing a research and community service information system according to the needs and become the portfolio of each user. This study will create a new feature in the research and community service information system, namely the user portfolio intended for prospective researchers. The process of research and community service at Universitas Negeri Medan carries out in stages, although it implements conventionally. Weak control over the implementation of these activities causes research and community service archives poorly documented. It makes it difficult for stakeholders to find documents when they are needed. The current technological developments have indicated the utilization of online databases to support human activities. Based on this, the actuality of a web-based research and community service information system used to record the research and community service process is essential. This study uses the waterfall method to ensure that the final product meets expectations by completing the communication, planning, modeling, construction, and deployment stages.

Keywords: Information System, Waterfall, Research, Community Service, Services

1. INTRODUCTION

The purpose of research and community service institutions is to produce research and community service by developing quality innovations as solutions to stakeholder problems in academic and non-academic fields. The creating a climate and culture of research and community service for lecturers and students through training, coaching and mentoring. Technological innovations creation is to encourage Indonesia's economic development by commercializing research results and community service. Provide solutions by academic studies of the needs, challenges, or problems faced by the community, either directly or indirectly. Carry out activities that can eradicate marginalized people (preference option for the poor) at all strata, namely people excluded economically, politically, socially, and culturally. Transferring technology, science, and art to the community for the development of human dignity and the preservation of natural resources. Produce scientific works, patents, and intellectual property rights used to improve the quality of research and community service. Produce research-based innovative products and community service that can enhance the image and reputation of Universitas Negeri Medan. Encourage creativity, innovation, and productivity of lecturers in conducting quality research and service at local, regional, national, and international levels. Produce research and service, development, and innovation services/products used to generate income. Enhance the function of the Research and Community Service Institute as a medium and means of scientific communication based on research results, community service, and innovation. The cooperating with various parties in the field of research and community service.

To achieve research outcomes by the Chancellor's contract with the Minister, the university by the RESEARCH AND COMMUNITY SERVICE INSTITUTION carries out research and service with University funds. The implementation of this research and service carries out to obtain research outputs which are reputable scientific publications, the number of Intellectual properties (IP), prototypes, and innovative products. The output is a product that supports the completion of innovation performance, research performance, and community service performance.

The research output accompanied by the adequacy of facilities and infrastructure seen from the up-to-date and relevant included facilities, equipment for learning, research, community service. In addition, the outputs supported are by formal documents in the form of policies and guidelines to integrate research activities and community service into learning. In addition, the availability of valid evidence regarding the implementation, evaluation, control, and continuous quality improvement that integrated research activities and community service into learning.

Formal documents in the form of valid evidence regarding the implementation of the research process cover six aspects, namely the procedure for evaluating reviewers, the legality of appointing reviewers, the results of the assessment of research proposals, the validity of the assignment of researchers' collaboration, minutes of monitoring and evaluation results, and research output documents. Currently, the research and community service institution is developing a research and

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 88-90, 2022, ISSN:-2319–8656
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community service information system by the needs also will integrate with the system at Universitas Negeri Medan.

2. METHOD

This study uses the Research and Development model. Research and development methods are research methods used to produce determined products and test the effectiveness of these products. The waterfall method uses as the development model of this study. So that, this study is carried out systematically and accounted.

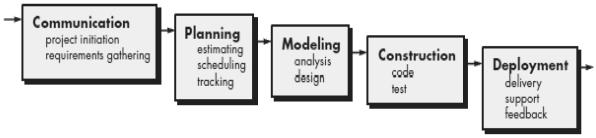

Figure 1. Waterfall Development Model

1. Communication
   The purpose of communication is to obtain an overview of the problems of research and community service. It also includes information about the wishes of the Research and Community Service Institute regarding the system to be built.
2. Planning
   In this stage, an in-depth analysis of the problems faced so far is carried out and determines alternative solutions to these problems.
3. Modeling
   At this stage, modeling the problems found. Design the system to be built.
4. Construction
   The application of the programming language takes place in this step. It bases on the designs created during the modeling stage. After the coding stage, system testing carries out to identify errors that may occur during the programming process. Then, if an error finds, it is corrected.
5. Deployment
   This stage is the distribution stage of a web-based information system, namely the system application in proposing research proposals and community service. So, the system can accommodate proposals submitted by lecturers and monitor implementation carried out by the Research and Community Service Institute.

3. RESULTS

In the analysis and development of research and community service information systems, several problems identify and the processes used to carry out research and community service activities, including the proposal process, implementation of proposal seminars, monitoring, and evaluation, to the final report. The deepening of the analysis found several functional requirements that must be available in application development. The development of research and community service information systems using website-based programming to make it accessible online. So that parties in this system can access it from anywhere and anytime by connecting to an internet connection. The results of the application construction made can describe as explained below:

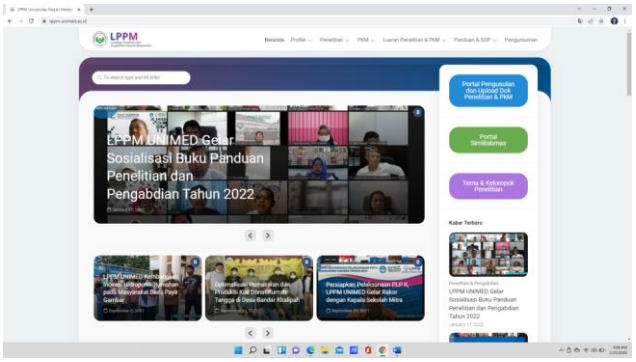

Figure 2. Page View of the Research and Community Service Institute

The process of proposing a proposal is carried out by the lecturer if he has logged into the information system. After that, the lecturer page will appear with menus specially provided for lecturers.

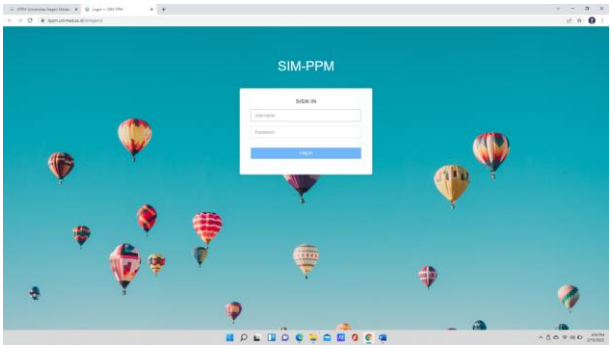

Figure 3. Login Page Display

To record the process of conducting research, SIMPPM will develop it by creating a user portfolio on the profile icon. The portfolio contains the researcher's identity by adding research history, dedication, journal articles, intellectual property rights, proceedings articles, books, and monumental works.

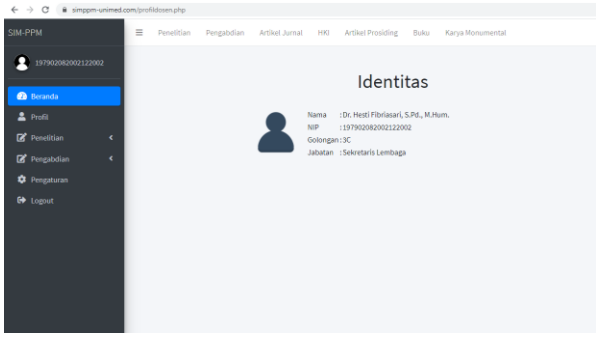

Figure 4. Researcher Profile Page

Proposals are submitted through each menu for research and community service. The proposal process is accessed through the "New proposal" sub-menu found in the navigation menu in the header.

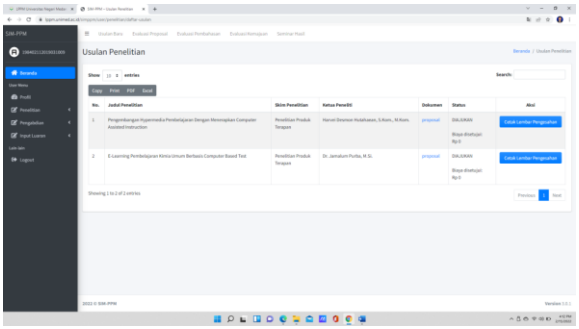

Figure 5. Proposal Page

The development of a research and community service information system at the Institute for Research and Community Service is essential to keep track of research and service funded by the university. In addition, the lecturer can fill in the results of the lecturer's work as curriculum vitae that will record in the system.

4. CONCLUSION

Based on the results obtained from the system analysis stage, the system design stage, the implementation stage to the testing stage, the development of Research Information Systems and services provides convenience in the process of submitting proposals because the submission process in the research information system has features that are tailored to the needs and by regulatory standards. The process of submitting research originally long can shorten by the existence of a research information system. Research and service information systems make the research process easy, fast, and structured.

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International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 91-97, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1002

Classification Algorithm for Career Recommendation System

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Abstract: The tremendous developments in technology that have been realized in this digital era have greatly improved the way in which data is collected and used in schools. Over the years the number of secondary schools using technology in processing student data has been increasing steadily. As a result, a large amount of data in electronic form has been gathered. Classification algorithms can be used to study the patterns presented in these data and use it to predict a suitable career for a student. In this study classification algorithms were used to predict a suitable career for form four students. The study evaluated the best classification algorithm for implementing the career recommendation system in Kenya. The Cross Industry Standard Process for Data Mining framework was applied to a dataset drawn from form four students in Bungoma County in Kenya. Stratified random sampling was used to select 50 secondary schools and a 10% of candidates were selected from every sampled schools. The collected data were cleansed, preprocessed and analyzed using a data mining tool of RapidMiner. Various classification algorithms were evaluated in predicting a suitable career for a student. The study findings revealed that classification algorithms can be used to predict a suitable career for a student. All the classifiers that were used gave a predictive accuracy of above 88% though deep learning was the most accurate with 97.5%. However, since the classifiers out performed each other in various metrics, therefore using multiple classification algorithms in building the recommendation model can yield better results. The study therefore concludes that classification models comprising of multiple classifiers can be used to predict suitable careers for secondary students.

Keywords: Rapidminer, Classification algorithm, Career choice, Recommendation system, Data mining

1. INTRODUCTION

In life people are constantly faced with situations where they must make choices and sometimes, they do so by basing on insufficient or lack of information of the available alternatives. The quality of the decision made is highly dependent on the available information. A decision on career choice for a secondary school student is so critical since it's the main determinant of their profession and greatly impacts them throughout their life (Mberia and Midigo, 2018). Furthermore, to make an effective decision the student must understand his/her interests and ability as well as have sufficient information about the available career alternatives. However, this isn't always possible since the main source of this information for the students in secondary schools in Kenya is their teachers and parents who in most cases are either unavailable or ill-equipped. As a result, most of them end up making choices which they later regret (Mudulia, 2017). However, the tremendous developments in technology that have been realized in this digital era have greatly improved the way in which such an exercise can be carried out. Currently artificial intelligence techniques are being used in various fields to aid the process of making decisions. One such a technique that is increasingly being used in the education field is Educational Data Mining (EDM).

EDM is an area of research which uses data mining tools and techniques in the analysis of raw data found in the institutions of learning. These tools analyze the various perspectives of the raw data to generate useful information (Han and Kamber, 2006; Raheela et al., 2017). The information may contain hidden patterns and associations which can be helpful in understanding students' environment and making decisions. The knowledge generated from this information can be useful in the validation and evaluation processes of the education systems which can result in improved quality of teaching and learning (Algarni, 2016).

Over the years the number of secondary schools using technology in processing student data has been increasing steadily. As a result, a large amount of data in electronic form has been gathered. Unless processed, this data is poor in information which may result in unreliable decision making. However, this data can be transformed into knowledge that can

improve decision making through Knowledge Discovery in Databases (Muhammad and Safawi, 2017; Suhirman et al, 2014).

Many studies have been done on the application of data mining in education. Though, most of these studies focused on predicting learner performance in institutions of higher education. The studies which have dealt with placement of students in various courses and careers include: Yadav and Pal (2017) used decision trees to select students for enrolment in particular courses. Nikita et al (2017) proposed use of RapidMiner mining tool to analyze educational data to suggest career options for high school student in India. Ansari (2017) developed a framework for career selection in Saudi Arabia using nearest neighbor technique. Wabwoba and Mwakondo (2011) proposed the use of trained Artificial Neural networks to select students by Joint admission board for university courses in Kenya. Stephen et al. (2016) used prediction and classification data mining techniques to predict students' enrolment in Science, Technology, Engineering and Mathematics (STEM) courses in higher education in Kenya.

Currently, there is a growing interest in the use of technology to improve decision making in educational institutions. In particular, there is an appreciation that most of the problems experienced in career selection require a new way of addressing them given the lack of an informed and intelligent way to exploit the available data. Therefore, there is an urgent need to identify new methods of analyzing a student's available data with a view of developing an academic profile that can guide in career selection. Thus, it's important to merge expert knowledge and computational techniques to aid in carrying out this exercise. This research aimed at evaluating classification algorithm for career recommendation in education.

2. RELATED WORK

The desire to have technology supported student advising systems accounts for the many studies that have been done in this area. Some of these studies have focused on the course advisory for both undergraduates and post graduate students while others have focused on career guidance for those joining the colleges and universities.

Ansari (2017) presents a framework design combining expert system and data mining techniques to predict a precise career for the scholars. The data used was collected from various public and private high institutions in Saudi Arabia. It comprised 11 career influencing factors contained in scholar's records. These are: Computer skills, office experience, location, financial status, interest, age, parent's culture, job security, medical insurance and children schooling. They used Nearest Neighbor (NN) technique to implement the tool. The main weakness of this framework is that it failed to take in to account some key factors influencing career choice such as student personality, availability of job opportunities and academic achievement.

Nikita et al (2017) designed a web application in Microsoft visual studio that would help high school students to select a course for their career. The system displays three questionnaires and then analyses the response to the questions using decision trees (C5 and C4.5 algorithm) to establish the students' personality, interest and capacity. This result forms the basis for recommendation of the career option by the system. This study took into consideration some key attributes that affect career choice. However, since it was done outside the country it doesn't take in to consideration some unique aspects in Kenyan system.

Elakia et al. (2014) used the RapidMiner data mining tool to show that data mining methods such as classification can be used to analyze student data in order to identify the suitable career options. They collected datasets from response sheets posted on the website based on Holland's self-directed search. The weakness of this system is that it only based the career recommendation on one attribute i.e. student personality.

The study by Yadav and Pal (as quoted by Stephen et al., 2016) developed a tool using ID3 decision tree algorithm to select student to be enrolled in a particular course by evaluating previous student performance. The limitation of this study is that it only considered the previous student performance and left out the other key attributes.

Stephen et al. (2016) used EDM Classification algorithms to predict student enrolment in science, technology, engineering and mathematics (STEM) courses. The study focused on how individual socio-demographic and contextual factors can determine student enrolment in STEM courses in high institutions in Kenya. The limitation of this study is that it only addressed the issue of learner enrolment in STEM causes.

Wabwoba and Mwakondo (2011) conducted a study on the use of artificial neural networks at Joint Admissions Board in selecting student's university courses for the students to study. The performance data for training was got from JAB and KNEC. They found out that if well trained the ANN application increases the chances of an applicant getting admitted in the career courses in which they are qualified. The limitation of this study is that it only focused on the use of a final exam (KCSE) which may not be representative enough.

In this study a framework that uses classification algorithms to analyze student data and recommend a suitable career for a secondary school student was developed. The study analyzed data collected from three key attributes and used it to build a model that can predict a suitable career for a student.

3. METHODS

The study followed the Cross Industry Standard Process for Data Mining (CRISP-DM) methodology as suggested by Nisbet, Elder and Miner (2009). This methodology has six phases as shown in figure 1 below. It is through these phases that the data mining tool to be used in a real environment is build and implemented.

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Volume 11–Issue 04, 91-97, 2022, ISSN:-2319–8656
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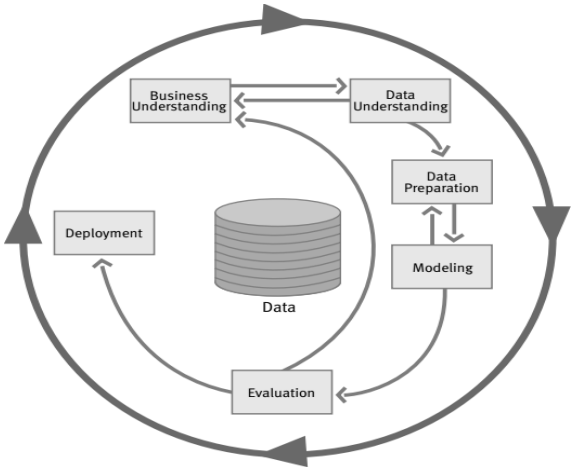

Figure 1: Cross Industry Standard Process for Data

The sub-sections that follow explains in details how the process was used in this study.

3.1 Business understanding phase

This research was developed in the context of secondary schools in Kenya. After admission in form one, a student undertakes a four-year study program and at the tail end selects a career to pursue later. During the admission process and throughout their stay in the school, a lot of student data is usually collected and stored either in the school database, in students' files kept by various departments and/or in the online platforms e.g. NEMIS (national education management information system) etc. However, the collected data may not be in the form which can easily be used therefore this may result in wastage of a precious asset of these institutions.

3.2 Data understanding phase

This phase begun with collecting the raw data from respondents. The collected data captured students' career preferences, their personality and academic achievement. The data was then checked for quality and then scrutinized to get some insights about it to enable formulating the hypothesis that can be used to extract the hidden information (Siraj & Abdoulha, 2009; Stephen et al., 2016).

3.3 Data preparation phase

3.3.1 Data preprocessing

This stage involved preparation of the data for analysis by filling the missing values in the data set, removing irrelevant attributes and selecting relevant ones using feature selection from the full set of attributes. The key attributes included: Sex, English grade, Kiswahili grade, Math grade, Biology grade, Physics grade, Chemistry grade, Religious Education grade, History grade, Geography grade, Technical & Applied grade, student's preference, student's personality and Recommended Career. The missing values in the Recommended Career attribute were manually filled by identifying the best two possible careers for the student based on the collected data. The student's personality was analysed by use of knowledge and rules that are based on Myers-Briggs Typology Indicator (MBTI) and Holland's Self Direct Search (SDS). Then the possible careers were determined from MBTI's Personality Analysis and job suitability Chart and Holland's Vocational Preference Inventory (VPI). These were analysed together with the student's career preferences and their academic achievement to determine the two most preferred careers.

3.3.2 Data transformation

The data was analyzed by a data mining software – RapidMiner. This software was used for implementing this research, since it has a variety of machine learning algorithms that are suitable for carrying out data mining tasks. After selecting the relevant attributes, the data was transformed into an Excel format for ease of analysis since the format (Excel) is acceptable by Rapidminer.

3.4 Modeling phase

The approach was to establish how data mining techniques especially classification techniques can be used to determine whether the selected variables could be used to predict a suitable career for a student. The study used Rapidminer to determine the performance of various classification algorithms based on a number of metrics. Their accuracy levels were evaluated to determine the most effective algorithms that could be used to implement the Recommendation system. The classification algorithms for prediction that were used include; Naïve Bayes, Deep Learning, Decision Tree, Random Forest, k-Nearest Neighbour, and Support Vector Machine. These classifiers are available in Rapidminer tool kit. The following metrics were used to determine the performance of the classification models: time taken to build the model, standard deviation, and prediction accuracy. The total correct predictions given by the algorithm was used to determine its accuracy. The accuracy of the predictive models was calculated based on the percentage of total predictions that were correct. Cross validation evaluation model was used in the final analysis. In this method all the data was divided into 10 disjointed sets of equal sizes. Evaluation was done iteratively such that each of the 10 disjoints took part in the testing and evaluation. Figure 2 shows the classification process.

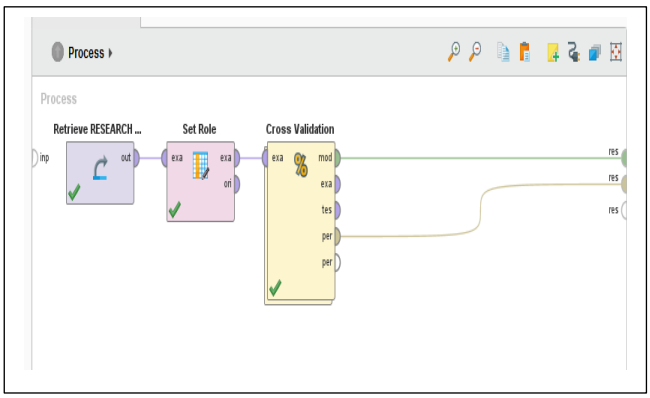

Figure 2: Classification Process

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 91-97, 2022, ISSN:-2319–8656
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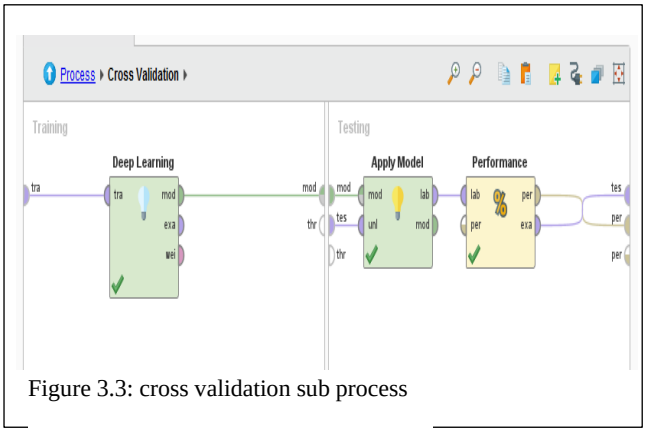

Figure 3.3: cross validation sub process

Figure 3 shows the cross validation sub process

3.5 Evaluation and deployment

This was the final phase of the research design. It involved testing the practical relevance and applicability of the recommender model. An expert survey was performed using focus groups to evaluate the perceived viability of the framework by comparing it with the existing solutions. Descriptive statistics was then be used to analyze these data.

4. RESULTS

The data collected was cleaned to identify the missing and incomplete questionnaires. Of the 455 questionnaires collected only 400 (87.9%) were completely filled. Mugenda (2012) notes that a response rate of 50% or more is adequate. Guided by these thoughts from renowned research academic giants, the response rate for this study was considered to be sufficient in forming conclusions and generalization of the study population.

4.1 Selection of attributes

The following attributes were selected for use in the classification: Sex, English grade, Kiswahili grade, Math grade, Biology grade, Physics grade, Chemistry grade, Religious Education grade, History grade, Geography grade, Technical & Applied grade, Student preference 1, Student preference 2, Student preference 3, SDS personality, MBTI personality, and Recommended Career. The data type of the attribute Sex was nominal while the rest had a data type of poly-nominal. A total of 455 instances were collected from the field.

4.2 Evaluating classification algorithm

The data collected from the students was preprocessed and then used as the input in the Rapidminer data mining tool for processing. Cross validation process was used to divide the data into two sets: training and testing datasets. Cross validation partitioned the data into ten disjoints; nine disjoints served as the training set and one as testing and validation set. The training data set was used to build the models. Six classification algorithms including: Deep Learning, Random Forest, k-Nearest Neighbour, Support Vector Machine, Decision Trees, and Naïve Bayes were used. The models that were obtained from the training data were rerun using the test and validation data sets to evaluate the performance of the resultant models. The process was done iteratively until each of the ten disjoints took part in training as well as testing of the model. The performance of the model was taken as the average of the processes. Six different classifiers were tested using two data sets on 4 parameters. The results are tabulated as shown in Table 1.

Table 1: Performance Measures for the Classifiers for the Career One Dataset

DATASET USED	**CAREER 1**			
CLASSIFIERS USED	MEASURES			
	% ACCURACY	**% ERROR**	**% STD DEV**	**RESPONSE TIME (s)**
Deep Learning	97.6	2.4	±5.0	62
Random Forest	95.6	4.4	±3.2	714
k-Nearest Neighbour	95.6	4.4	±3.2	362
Support Vector Machine	96.6	3.4	±3.2	299
Decision Tree	88.4	11.6	±3.8	59
Naïve Bayes	96.6	3.4	±12.4	54

Table 2: Performance Measures for the Classifiers for the Career Two Dataset

DATASET USED	**CAREER 2**			
CLASSIFIERS USED	MEASURES			
	% ACCURACY	**% ERROR**	**STD DEV**	**TIME (s)**
Deep Learning	87.3	12.7	±2.2	36
Random Forest	85.2	14.8	±2.2	219
k-Nearest Neighbour	86.3	13.7	±2.2	327
Support Vector Machine	87.3	12.7	±2.2	229

Decision Tree	67.6	32.4	±3.2	28
Naïve Bayes	86.5	13.5	±2.2	33

It was noted that most classifiers almost shared the same accuracy, therefore accuracy alone is not the sole determinant in selecting the best classifier. The time taken to build the model, and the standard deviation were also considered in determining the effectiveness of these classifiers.

From table 1, it can be noted Deep Learning classifier achieved highest classification accuracy of 97.6%, with a standard deviation of ±5.0 and response time of 62s. This was closely followed by Support Vector Machine (SVM) and Naïve Bayes (NB) classifiers with a classification accuracy of 96.6%. The standard deviations of SVM and NB were ±3.2% and ±12.4% respectively. SVM had a response time of 299s and NB 54s. Both kNN and Random Forest had an accuracy of 95.6% and a standard deviation of ±3.2%. However, kNN was found to have a better response time of (362s) while random Forest (714s). The classifier that had the lowest accuracy was Decision Tree at 88.4% with a standard deviation of ±3.8 and a response time of 59s.

From Table 2, it's noticed, all classifiers had the same standard deviations of ±2.2%, apart from the Decision Tree classifier (±3.2%). However, they varied in their classification accuracy and response time. Deep Learning (DL) and Support Vector Machine achieved the same classification accuracy of 87.3% but DL had a better response time of 36s as opposed to SVM's 229s. NB followed closely with an accuracy of 86.5%, with a response time of 33s, kNN had an accuracy of 86.3% and a response time of 327s, Random Forest had an accuracy of 86.3s and a response time of 219s, Decision Tree classifier is the one that had the lowest accuracy of 67.6% and a response time of 28s

From the above results it is evident that the deep learning based classifier outperforms other classifiers in predicting both the first career choice and the second followed by support vector machine.

4.3 Career Recommender System

Currently recommendation frameworks are used in areas where there is overwhelming data. This allows the clients to concentrate only on significant areas of interest. The career recommender system aims at providing a career guidance and prediction at student's level so that they comply with the guaranteed requirements. Its input consists of (1) student data (2) career selection procedure (3) cluster subjects. The prediction and career paths are the output. The system focuses on classifying student data and recommending a suitable career path.

The architecture of the career recommendation system was simulated as in Figure 4.

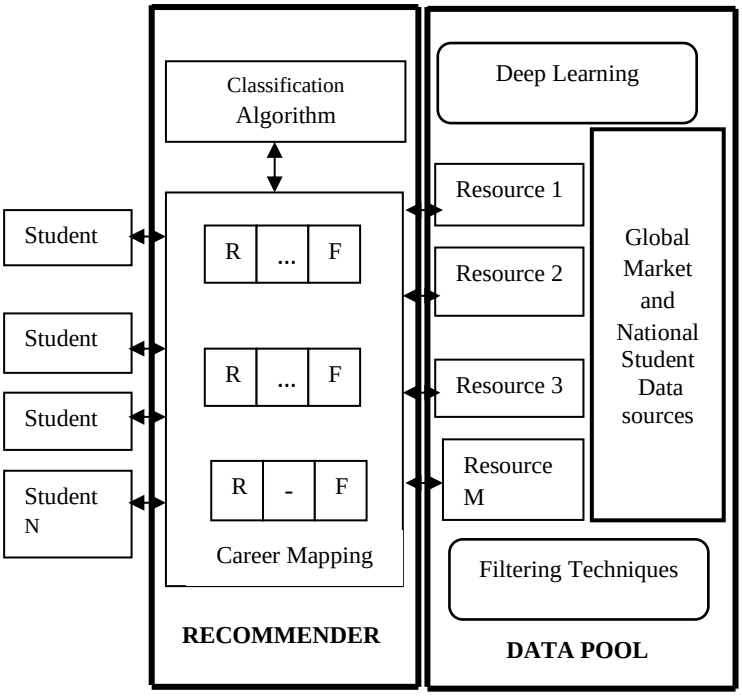

Figure 4: Architecture of Recommender Algorithm

Figure 4 presents a summary of classification algorithms for implementing Career recommender system in secondary schools. At the heart of the recommender system is the classification algorithm for classifying student data, career mapping that assigns a validated career path to a client (student or career master). The recommendation is generated and classified on priority basis i.e. highest priority path to the lowest likely path during mapping process. The F denoting the first student priority career path and R denoting the lowest student priority path which varies due different signatures of data that is unique to different students' capabilities and nature of subjects offered in the school.

The data pool define a repository of mixture of data and various techniques of accessing and machine learning techniques. The pool has unique data sources denoted as resources with a set of numbers {1, 2, .. M} as sub-servers for different school which comprises student data from different levels, global market and National student data sources which provides that on dynamics of market demands and general data as regulated in NEMIS (government planning and monitoring). Deep learning algorithms are used to enable training and learning process for accurate storage of data in the resource data set for accurate classification and career mapping. Filtering algorithm filters the relevant global data toward unified career decision making in the recommender system. Model clients i.e. students and career masters denoted as a set of student {1, 2, 3,…, N} defines the set of requests for career path services from the recommender which are handled in a hand-shake manner.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Study Summary

The purpose of pursuing this study was to evaluate the best classification algorithm for implementing the career recommendation system. To achieve the objective the researcher collected data from form four students on the three key attributes: personality, interest and academic achievement. This data was preprocessed and acted as the input in the RapidMiner data mining tool that evaluated the performance of the various classification algorithms in predicting the suitable career for a student. It was noted that deep learning and support vector machine algorithms out-performed other algorithms in this exercise as seen in tables 1 and 2.

The study further came up with an architecture of career recommender system that uses a variety classification algorithms. It was noted that recommender system for implementing Career recommendation in secondary schools has at the heart a classification algorithm for classifying student data and a career mapping algorithm that assigns a validate career path to a client (student or career master). The recommendation is generated and classified on priority basis i.e. highest priority path to the lowest likely path during mapping process. The mapping process is as represented in figure 3 having F denoting the first student priority career path and R denoting the lowest student priority path which varies due to different signatures of data that is unique to different students' capabilities and nature of subjects offered in the school. The data pool define a repository of mixture of data and various techniques of accessing and machine learning techniques. The pool has unique data sources denoted as resources with a set of numbers {1, 2, .., M} as sub-servers for different schools which comprises student data from different levels, global market and National student data sources which provides that on dynamics of market demands and general data as regulated in NEMIS (government planning and monitoring). Deep learning algorithms are used to enable training and learning process for accurate storage of data in the resource data set for accurate classification and career mapping. Filtering algorithm filters the relevant global data toward unified career decision making in the recommender system. Model clients i.e. students and career masters denoted as a set

5.2 Conclusion from the Study

The study revealed that classification algorithms can be used to predict a suitable career for a student. All the classifiers that were used gave a predictive accuracy of above 88% for the first choice though deep learning was the most accurate with 97.5%. However, since the classifiers out performed each other in various metrics, therefore using multiple classification algorithms in building the recommendation model can yield better results. The study therefore concludes that classification models comprising of multiple classifiers can be used to predict suitable careers for secondary students.

5.3 Recommendation from the Study

This study recommends that Multiple classification algorithms to be used in building the recommendation models. This is because the classification algorithms that were used to build the classification models out performed each other in various metrics, therefore using multiple classification algorithms can yield better results.

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International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 98-102, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1003

Technology-Enabled Self-directed Learning in Developing countries: Adoption Framework

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Abstract: 21st century-learning approach is characterized by self-directedness and the ability to learn anytime, anywhere. Self-directed learning heavily depends on Technology to be effective. Most universities were used to conventional face-to-face learning, but uncertainties like the covid-19 pandemic have challenged this teaching and learning mode, thus pushing universities to explore innovative learning approaches to ensure seamless learning. One such approach is Technology-enhanced self-directed learning. Most developed countries are endowed with enabling infrastructure to actualize this learning approach. However, most developing countries like Kenya are still struggling to adopt self-directed learning due to technological, organizational, and environmental challenges. A framework is needed to guide its adoption. A survey research design using an online questionnaire with a sample size of 572 was used. Four Kenyan public university students participated in the study. Data was collected and analyzed using Exploratory Factor Analysis. Principle component analysis extracted seven factors explaining a total variance of 62.5%. The factors were renamed based on a shared theme, and the average factor loading for each construct was calculated. A percentage weight of each construct was also calculated. Key factors forming the constructs of Technology-enhanced self-directed learning were: E-learning infrastructure, bring your own device policy, Connectivity infrastructure, ICT Competencies, Information security, demographic factors, and laptop ownership program.

Key Words: Self-directed learning, Bring your own device (BYOD), exploratory factor analysis, technology-enhanced self-directed learning

1. INTRODUCTION

The current COVID-19 pandemic has wreaked havoc on the school system globally, impacting more than 94 percent of the student population [1]. An almost uniform response to school closures brought about by Covid 19 pandemic has been establishing online learning systems to help instructors, students, and families [2]. This teaching and learning approach requires learners to be self-directed and use computing devices and internet technologies to access and share information.

Self-directed learning is defined by Knowles [3] as a process in which individuals, with or without the help of others, diagnose their learning needs, formulate their learning goals, identify human and material resources for learning, choose and implement appropriate learning strategies, and evaluate their learning outcomes. In an increasingly complex and uncertain environment, self-directed learning is an essential skill for living and working. For instance, self-directed learning was cited by global education leaders as one of the education responses towards the COVID 19 pandemic [4]. The potential of Technology to promote self-directed learning has arisen in education during the previous two decades, as Francis [5] points out. Historically, schools have depended on Technology to assist a variety of teaching and learning initiatives. Rapid technological advancements have displaced the personal computer as the dominating technology fixture in classrooms, with laptops, tablets, and smartphones becoming more widely available and inexpensive. When combined with widespread broadband internet access, introducing these gadgets has allowed teachers more freedom in how they help their students. Higher education institutions all over the globe have acknowledged the necessity to employ Technology in teaching and learning for particular reasons due to the widespread use of Technology among today's college and university students [6]. The growth in popularity of YouTube and dozens of other websites dedicated to providing users with online lessons and other relevant material has influenced how today's learners learn [7]. These online and other self-directed educational options have exploded in popularity in recent years, with a possibility of most courses being undertaken online in a self-directed learning format.

The education systems in developed nations are evolving to take full advantage of the potential of mobile technology devices to inspire learning. For instance, across Europe, governments, regions, and schools have been making significant investments in ICT connectivity, equipment, and services to create digital age teaching and learning reality for young people and to equip them with the competencies needed to thrive in the 21st century [8]. However, in developing countries, the rate of technology use is slow, even though most tertiary students and lecturers already own one or more computing devices and are familiar with using them for personal and educational purposes (Ruxwana, Msibi, & Mahlangu, 2019).

Using exploratory factor analysis, this study attempts to uncover variables that impact the usage of Technology in self-directed learning in developing nations (EFA). EFA is used when a researcher intends to discover the number of factors influencing manifest variables and analyze which manifest variables are more closely correlated [9]. A group of most correlated manifest variables makes a factor or latent variable [9], [10]. Exploratory factor analysis is considered by Yong & Pearce [10] as a more robust way of identifying factors. Furthermore, Boison & Dzidonu [11] provided a framework for carrying out EFA to identify factors.

2. METHODOLOGY

A survey was conducted on students of four Kenyan public universities in May/June 2021. The sample size for this study was 572 obtained using a simplified formula for proportions [12]. Formula $n = \frac{N}{1+N(e^2)}$. A 95% (0.95) confidence level

corresponds to a 5% (0.05) level of precision, and N as the target population was adopted.

Subjects & selection method: The respondents were selected using a simple random sampling technique.

Procedure methodology: Before embarking on data collection, permission to collect data was granted by the school of graduate studies at Kibabii University, the National Council for science technology and innovation (NACOSTI), and the respective Universities. An online questionnaire was the primary data collection instrument. An online questionnaire was preferred over the physical questionnaire to comply with covid-19 pandemic containment measures. Out of the 572 online questionnaires randomly sent out, 350 (61%) were duly filled and returned for analysis. [13] Reiterates that return rates of 50% are acceptable to analyze and publish, 60% is good, and 70% is excellent.

Statistical analysis

Data was analyzed using SPSS version 20 (SPSS Inc., Chicago, IL). Exploratory factor analysis was used to identify the factors.

3. RESULTS

Before performing exploratory factor analysis, the suitability of data for factor analysis was assessed. The researcher investigated the Kaiser–Meyer–Olkin (KMO) statistic and Bartlett's test of sphericity. Table 5.1 gives the summary.

Table 1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.866
Bartlett's Test of Sphericity	Approx. Chi-Square	9045.487
	df	820
	Sig.	.000

As indicated in table 1, the Kaiser- Meyer-Olkin value was .866, exceeding the recommended value of .6 [14], and Bartlett's[15] Test of Sphericity reached statistical significance, supporting the factorability of the correlation matrix.

For this study, the 38 items of the Technology-enhanced self-directed learning questionnaire were subjected to principal components analysis (PCA) using SPSS version 20. Principal components analysis revealed the presence of ten components with eigenvalues exceeding 1. Consequently the components that contributed to the framework development includes 1-10 with their respective common variance and subsequent Eigenvalue are as indicated: Component 1: 30.9%(12.7), component 2: 7.7%(3.1), component 3: 7.2%(2.9), component 4: 4.9%(2.0), component 5: 4.3%(1.7), component 6: 3.9%(1.6), component 7: 3.38%(1.3), component 8: 3.1%(1.2), component 9: 2.7%(1.1), component 10: 2.5%(1.0). The components cumulatively explain 70.9% of the variance. An inspection of the scree plot revealed a break after the seventh component. Using Catell's [16] scree test, it was tentatively decided to retain seven components for further investigation.

Further investigation of the least components required was carried out using parallel analysis software [17]. The randomly generated eigenvalues were compared with actual eigenvalues. The results are as presented in Table 1

Table 2: Parallel Analysis

No	Random Eigen value	Actual Eigen value	status
1	1.7319	12.702	Accepted
2	1.6403	3.173	Accepted
3	1.5721	2.966	Accepted
4	1.5162	2.018	Accepted
5	1.4659	1.770	Accepted
6	1.4212	1.638	Accepted
7	1.3793	1.387	Accepted
8	1.3366	1.278	Rejected
9	1.2996	1.113	Rejected
10	1.2626	1.048	Rejected

For a randomly created data matrix of the same size (38 variables 308 respondents), the parallel analysis revealed seven components with eigenvalues surpassing the appropriate criteria values. It was decided to retain seven components based on parallel analysis results. The seven-component solution explained a total of 62.57% of the variance, with Component 1 contributing 30.9.0% , Component 2 contributing 7.7%, Component 3 contributing 7.2% , Component 4 contributing 4.9%, component 5 contributing 4.3%, component 6 contributing 3.9% and component 7 contributing 3.38% .

With seven variables to extract, the principal components analysis was performed. Varimax with Kaiser Normalization was utilized as the rotation technique. Only factor loading coefficients above 0.54 were considered.

4. DISCUSSIONS

Nine factors loaded on component 1 the factors have a common theme of E-Learning Infrastructure. Therefore, the factor loadings were recombined and renamed E-learning infrastructure. The average factor loading of component 1 factors is 0.723. It implies that an e-learning system that supports self-directed learning adoption must have the following components: an online learning department, a Learning management system, E-library, students' portal, University provided E-notes, open online learning resources. The university should also specify the minimum requirements for a computing device to ensure compatibility and efficiency in using online resources. The university should also develop a personal computing device management policy to guide learners on managing their devices.

Six items loaded on component two with average loading of 0.824. The items have a common theme of "use of personal computing device". Hence, the items were recombined and named bring/use your own device (BYOD Policy). It implies that Universities should adopt the BYOD policy to ensure self-directed learning takes place anywhere, anytime.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 98-102, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1003

Seven Items loaded on component three with an average factor loading of 0.552. The items have a common theme of "Internet and power supply connectivity". Hence, the items were recombined and named connectivity infrastructure. It implies that a Reliable power supply, power surge safety measures, sufficient sockets, reliable home power supply, Reliable university internet connection, wide Wi-Fi coverage, and Network security are critical components of connectivity infrastructure.

Five Items loaded on component four had an average loading of 0.679. The components had a common theme of ICT competencies. Hence, the factors were recombined and named ICT Competencies. The ICT training policy should cover the competencies such as information management, information searching, and information sharing.

Network information access control and cyber security training loaded on component five with an average loading of 0.615. The two factors were recombined and named Information security. It implies that universities should enhance Information security by controlling information accessed through the institution's network and developing a cyber-security training program.

Three Factors loaded on component six with an average factor loading of 0.783. The Factors were recombined and named Demographic Factors. It implies that self-directed learning programs may be influenced by the age of learners, Level of education, and Experience.

Two factors loaded on component 7: device loaning policy with a factor loading of 0.564 and Gender with a factor loading of -0.599. Therefore, the Device loaning policy was considered with a loading of 0.564.

5. FRAMEWORK

Seven key constructs were used to develop the framework. The weight of each construct was indicated to show its percentage contribution to the framework. The importance of each construct was calculated as shown below:

Table 2: Framework Constructs Summary

Component	Constructs	Average factor Loadings	Weighted Score
1	Online Learning Platforms (OLP)	0.723	0.723/4.7695 =0.15
2	Bring Your Own Device (BYOD)	0.769	0.769/4.7695 =0.16
3	Connectivity Infrastructure (CI)	0.63	0.63/4.7695 =0.13
4	ICT Skills (IS)	0.683	0.683/4.7695 =0.14
5	Network Security (NS)	0.6	0.6/4.7695 =0.13
6	Learner Demographics (LD)	0.783	0.783/4.7695 =0.17
7	Computing Device ownership support program (CDOP)	0.5815	0.5815/4.7695 =0.12
	TOTAL	**4.7695**	**1.00**

Seven key constructs were used to develop the framework. The weight of each construct was indicated to show its percentage contribution to the framework. The weight of each construct was calculated as shown in Table 5.13. The construct weights represent the construct contribution to the framework.

Self-directed learning Framework (**SDL**) can be summarized using the equation:
SDLF (1) =OLP (.15) + BYOD (.16) + CI (.13) +IS (.14) +NS (.13) +LD (.17) +CDOP (.12)
Figure 1 is the diagrammatic representation of the self-directed learning adoption framework.

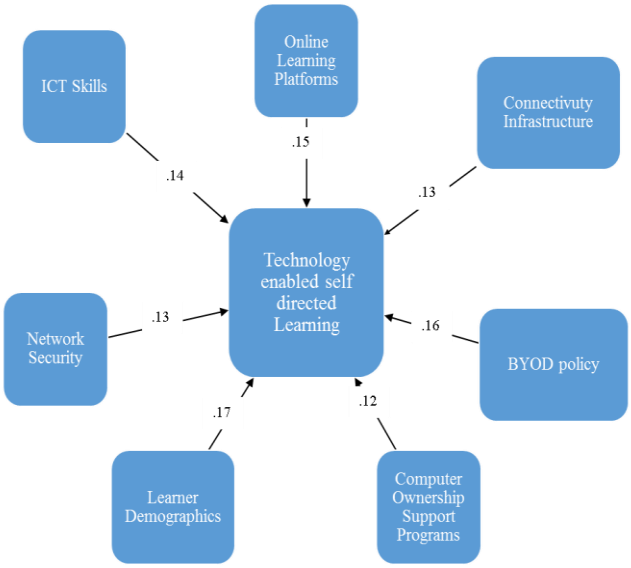

Figure 1: Technology Enabled Self-directed learning Framework (TESDLF)

As indicated in figure 1, the Online learning platforms construct has a weighted score of 0.15. It implies that online learning platforms such as e-library, learning management systems, virtual learning applications, and digital learning resources also play a critical role in the successful adoption of self-directed learning. The Bring your own device construct contributes 0.16 to the framework. Universities should

formalize the BYOD since majority of students own computing devices. Connectivity Infrastructure has a contribution of 0.13 to the framework. This implies that for self-directed learning to be effective, universities should put infrastructures such as reliable power systems and internet connectivity. ICT skills construct has a weighted score of 0.14. This implies that Universities should develop ICT training programs to enable learners to acquire core ICT skills. Network security has a weighted score of 0.13. This implies that Universities should develop robust network security measures to protect their network. Learner demographics construct has a weighted score of 0.17. This construct has the highest contribution to the framework. This implies that learner demographics such as age, experience, and level of education should be considered while implementing self-directed learning. Device ownership support program construct has a weighted score of 0.12. This implies that universities should develop programs to assist learners in owning computing devices since these devices play a critical role in self-directed earning.

6. FRAMEWORK VALIDATION

Validation activity is a portion of the procedure of framework development. This phase was carried out to ensure the framework designed is adequately precise for its intended purpose. The constructs of the framework were presented to the experts in order to determine if 1) presented constructs gives a perfect replication that supports the study, 2) the constructs signify the area of study 3) if the constructs given attention can be modeled to fit in the world that is real, as well as 4,) if the framework developed and presented would be accepted in the targeted domain. The seminar involved (7) online teaching experts and (10) Information technology experts. Table 3 indicates the responses summary.

Table 3: Responses summary

Question	Strongly Disagree	Disagree	Agree	Strongly Agree
The framework is a representation of the real world	0	0	13(76.5%)	4 (23.5%)
The framework is an accurate representation of the concepts of this study	0	0	15 (88.2%)	2 (11.8%)
The framework is easy to use or apply to the real world	0	0	3 (17.6%)	14 (82.4%)

The responses on whether the framework represents the real world indicate that 76.5% agree while 23.5% strongly agree. This implies that the Majority of the respondents agree that the developed framework represents the real world. On enquiring whether the framework is an accurate representation of the concepts of this study, 88.2% agree, while 11.8% strongly agree. This implies that the majority of the respondents agree that the framework is an accurate representation of the concepts of this study. To establish whether the framework is easy to use or apply to the real world, 17.6%agree while 82.4% strongly agree. This implies that most of the respondents agree that the framework is easy to use or apply to the real world.

7. CONCLUSION

Factors that influence Technology-enhanced self-directed learning are E-learning infrastructure, Bring your own device (BYOD) policy, Connectivity infrastructure (Power and internet), ICT Skills, Information security, Demographic factors, and Laptop loaning program. These factors are consistent with OECD [2]. To ensure seamless learning, especially during the Covid 19 pandemic and beyond, Kenya and other developing countries should consider these factors.

8. ACKNOWLEDGMENT

I acknowledge Prof. Mbugua Samuel PhD, CEng and Dr Anselemo P, PhD, for their scholarly support in this study.

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International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 103-117, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1001

Affordances of Successful Blended Learning Implementation in Higher Education: A Case Based Study

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Abstract: Over the last couple of decades, online learning has been growing in line with growing computer-based technology to the now almost fully fledged e-learning supported by artificial intelligence. Early predictions foresaw a case whereby the teacher would be fully supported or even replaced by technology in the delivery of content and assessment of learning. This is an area that has remained the subject of inquiry and technology around the concept is still evolving. The onset of COVID -19 pandemic in 2020 saw many universities having to turn to online learning to complete their courses. The emergency movement to remote teaching caught many universities unaware, but several lessons were also learned. With time, humanity is coming to appreciate that COVID19 is endemic. We have thus experienced a resumption of classes. With social distancing still being a requirement, most universities are now turning to blended learning in order to benefit from the affordances of face to face teaching and also leverage on existing technology, it is imperative to review the critical success factors that come into play for successful implementation of blended learning. This case study looks at one of the first private universities to resume studies in a blended mode during the pandemic in Kenya. It evaluates the key areas that have to be attended to for a successful transition to blended learning. The study identifies Organizational affordances, Academic affordances (Programs, assessments and examinations), Technological Affordances, Digital Resources affordances and Pedagogical affordances as crucial for successful implementation of blended learning.

Keywords: blended learning; successful implementation; higher education; affordances; technology.

1. INTRODUCTION

The contribution of Information Communications Technology in the teaching and learning process can not be underestimated as approaches allow learning to take place both inside the campus. Distance education has existed over several decades, especially with the development of the mailing system that allowed correspondence learning. The rapid spread of the Internet has facilitated learning in multiple and diverse formats, especially enhancing learning from remote locations and also blending several delivery approaches. Distance learning has long supported the spread of higher education by enabling allowing anyone willing to learn to gain access to do so (Elleithy &Sobh, 2015; Holt, Segrave & Cybulski, 2012). In addition, mixed forms of face-to-face learning and online learning provides a

blended learning environment where students obtain knowledge through the combination of traditional and online learning (Siemens, Gašević, & Dawson, 2015). For effective blended learning to take place, technological, pedagogical people and organizational issues should be put in place.

Torrisi-Steele (2011) defines blended learning as "enriched, student-centered learning experiences made possible by the harmonious integration of various strategies, achieved by combining f2f interaction with ICT.' (p.366). It comprises of several innovative concepts that are derived from the intersection of the traditional classroom and learning that is supported by ICT for offline and online teaching and learning. Some of the key supporting concepts include computer-aided learning, constructive and collaborative learning. To achieve the desired scope of blending, the concerned parties should demonstrate the right attitude, rigor, and high motivation for both teachers and students, and the administrators should be prepared to spend a substantive budget on the same (Dangwal, 2017; Apandi &Raman, 2020). The incorporation of diverse modes makes blended learning a complex concept that should be carefully planned and organized in order to succeed. If well organized, blended learning can bring together an interactive learning environment that combines online and classroom learning activities that can lead to optimal use of resources in order to improve learning outcomes and also address important institutional concerns (Kaur, 2013; Garrison, Anderson & Archer, 2000)

In the beginning of 2000, Blended learning emerged as one of the most popular pedagogical concepts. Many institutions have adopted this mode, although technological affordances have prevented it from flourishing. However, in the recent last, and with the onset of Web 2,0 and web 3.0, traditional learning has been blended with distributed learning environments (Guzer & Caner, 2014). The onset of COVID-19 pandemic made it almost mandatory for institutions of higher learning to take up blended learning. Blended learning is credited for being easily adaptable to learners needs, since online resources can be used in many ways to bring in the much desired flexibility. The learner and the faculty can change the learning materials and activities to suit the specific learning conditions. Blended learning is also known to involve the learner in planning process, resulting in creativity and critical thinking. In addition, it can help create independent learners and reduce the instructors' workload in the process. The time saved can be used in creating more strategic resources and materials. No wonder this was one of the fall back approaches used by many institutions during and post COVID-19 education.

Currently successful blended learning is created using tablets, smart phones and touch screen technologies and modern communication aps such as Facebook, Twitter, WhatsApp, YouTube and videoconferencing software. As these technological applications spread, it is important to study how to blend the various concepts in order to improve the learning outcomes and also benefit the institutions. Of great interest now is how to identify and use digital tools and platforms with advanced human-computer interactions and automation capabilities of these tools to create intelligent tutoring systems that improve learning and also facilitate self-paced learning and improve collaborative

learning, assessment and feedback (Castro, 2019).

The main players in the successful implantation are the faculty who need to know how to use the technology effectively, the learners who must not only know how to use the technology but must be aware of how to self-regulate, as well as the institutions who must provide suitable instructional technology and support but also train both faculty and students (Rashhed, Kamsin& Abdullah, 2020; Singh, 2021). Moreover, there is still need to investigate how modern Universities have positioned online learning with respect to on-campus and off campus learning as learning current research shows that higher education largely focused on curriculum development and content design (Gros & Garcia-Penalvo, 2016), which might have left out other crucial factors for effective blending focused on content design and curriculum development. However, in order to develop personalization, adaptive learning is crucial.

The main purpose of this study is to document, review, and analyses how one University successfully migrated to blended learning and to document the affordances that are to be considered for successful blended learning implementation.

2. LITERATURE REVIEW

2.1 Blended Learning

Many authors have given varying definitions of blended learning. It is important to articulate the form that one is dealing with in order to successfully identify the critical success factors that would lead to its successful implementation. Some authors have described it a combination of traditional face to face teaching and online teaching, usually using learning technologies in a virtual learning environment using Learning Management Systems (LMS) such as Moodle, Canvas or blackboard. Such a description categorizes learning as both synchronous and asynchronous with live chats and bulletin boards used for collaborative purposes. (Sharma, 2010; Gearhart 2010)

Another definition of blended learning is a combination of technologies, media and tools in a purely distance learning course taken over the internet (Hamalainen & Hakkinen, 2010; Anthony et al, 2020), without much concern and organizational factors. The technology to use is largely pushed to the learner with the University only providing the content (Maeroff, 2003; Hadjar &Gross, 2016). Others define it as a combination of a combination of methodologies and pedagogical approaches without much consideration of the learning technologies in use, and consider constructivist, collaborative or transmission approaches only (Miller, 2014). Many other terms such as the flipped classroom fit into this category (Gearhart, 2010) as practitioners try to improve the learning outcomes.

For purposes of this study, we define blended learning on the basis of a combination of face to face learning and the use of ICT and online technologies to complement and supplement the teaching and learning and improve the learning outcomes.

2.1 Blended Learning Affordances

According to Gibson (1977), an affordance is a pre-condition for an activity, and it

describes action possibilities available in the environment for an actor. An affordance arises from the user-artifact relationship, and affects how the actor will use the artifact to arrive at a certain goal. Although the theory of affordances has been used in many Information System Research projects, and mainly refereeing to technology, other non-technology artifacts have been included in such studies.

Blended learning borrows heavily from both online and face to face learning, with technology being the mediating factor. In all teaching and learning situations, the focus should be the learner and the Learning Outcomes. A successful blended learning environment should therefore ensure that the learner has the option of ether modes. This allows a personal interaction with the instructor and the classmates and also the option of ICT supported learning, depending on the nature of the content and the objectives to be achieved. Instructional designers and the instructors can also help (Manhas, 2012; Iskander, 2008). Another important feature of the blended learning is that the instructors need to be very dynamic, techno savvy and fully trained to effectively teach in both face to face and online modes (Ololube, 2014), and both classrooms should be well equipped with the requisite technologies efficiently in both the formats-traditional classroom format and ICT supported format. In the blended mode, the students get sufficient time to interact with other students pursuing the same course (Henri& Pudelko, 2003) and they get to interact with them inside on campus and also off campus (Gorjanc, Egorova & Zitec, 2016). This enlarges the circle and therefore the diversity of the student's knowledge (Mukama, 2010), creating a learning community across courses, cultures and countries.

We are living in the age of technology, and blended learning helps to augment the learner's ICT literacy (Palloff & Prat, 2009, especially where innovative technologies such as virtual labs, simulations and artificial intelligence are blended in with face to face learning. When these learners meet the same technology in their final workplace, the benefits can be amazing. Blended learning allows students to get skills in multiple areas of life and work, and also to practice these skills as they move from one mode to another. Having to switch from an online platform to a face to face class allows empathy, decision making capability, critical thinking, patience, self-management and communication (Parsons, 2016; Raiker 2009), allowing the learner to consume and also construct knowledge. It also helps to build an all-round personality (Wankel & Blessinger, 2013). The Tradition classroom setup is helpful in the cognitive domain development while the behavior, lab experience and social group with classmates develop affective and physical domain (Stahl, 2010) while online experiences build a reflective level of learning. If used correctly, so develop higher faculties social networking sites and other social interactions through the internet develop the right values (Vickers, Field & Melakoski, 2015).

Unlike pure online learning, blended learning allows for sports and other exercises that are good for the body (So & Bonk, 2010) as well as get a wide exposure to new perspectives of the course content (Salmon, 2004) and gives learning a human touch (Visser, 2012). Furthermore, it provides a multidimensional approach to the teaching and learning process (Simonson,

2014) and allows the instructor to play diverse roles (Romero& Lambropoulos, 2011: Pandey 2017). If well implemented, blended learning can exploit the benefits of flexibility of time, place and other constraints and also create worthwhile collaborations and interactions between the faculty and the learners. It can also enable the learner-centered approach to be established more effectively (Dewi, Ciptayani, & Surjono,2018). However, the same drawbacks of face to face learning may exist, since most online courses are designed in a similar manner as the face to face ones, and taught by the same instructors and in a similar approach (Buran& Evseeva, 2015), perhaps due to lack of resources or due to lack of professional development of the instructors.

According to Dewi, Ciptayani& Surjono (2018), the critical success factors for blended learning include (a) infrastructure, (b) integration (IT, content, and learning process), (c) professional development (teacher, student, and information system management), (d) Support (policy and financial), (e) culture (attitude). Proponents of blended learning request that Universities provide extra computing resources such as servers, bandwidth and storage capacity (Soomro et al; 2018), but also develop comprehensive institutional and organizational environments to promote the establishment of blended learning. .Khans Octagonal Framework (Khan, 2005) Identified eight dimensions for meaningful E-learning: Institutional, technological, interface design, evaluation, management, resource support, pedagogical and ethical issues.

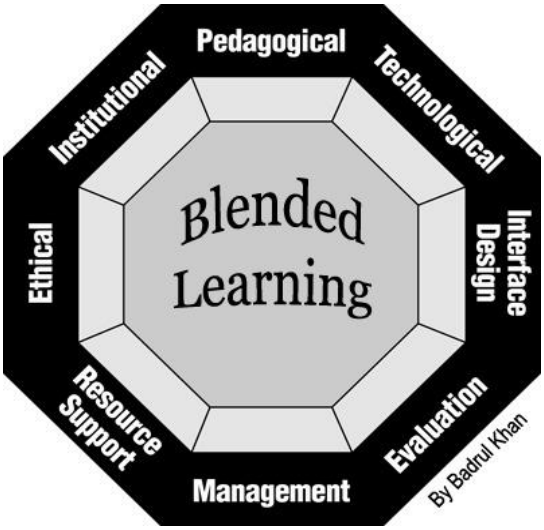

Fig 1. Khan's Octagonal Framework (Khan, 2005)

The institutional dimension reviews organizational and administrative issues that address the level of preparedness of the institutional to offer blended learning, and can easily be picked from needs assessment. Pedagogical issues have to do with instructional design such as analysis of the content, the learner needs, the objectives and the desired learning outcomes as well as the design and strategy of the blended mode. The technological dimension aspires to create a learning environment that has the requisite technology such as the Learning Management Systems and other technical requirements such as servers, bandwidth and related infrastructure. The Interface design issues relate to how the different elements relate with each other, the navigability and content structure and help of all the related elements. The evaluation dimension is concerned with the program is able to evaluate the performance of each learner and

the evaluation method to be used for each delivery type (Khan, 2005).

The management dimension is concerned with the logistics of managing both the face to face and technology aspect of the mode in order to integrate them seamlessly, and how issue such as registration and scheduling and handled. Resource support ensures that the different types of resources are well organized and available for the learners. This dimension could be managed by personnel or could even be automated. The ethical dimension addresses issues such as equal opportunities, cultural and national diversity since blended learning reaches out to learners from diverse backgrounds sometimes on a global scale. (Singh, 2021). Given all these factors, it is important to establish how unique institutions have handled the implementation of blended learning and the unique experiences they have gone through.

Based on the work of Khan (2005) on the critical success factors for blended learning, and the work of Gibson (1977) on the affordances theory, it is critical to evaluate how these two great works came to play in institutions of higher learning during the COVID-19 pandemic. study sets out to address this knowledge gap.

3. METHODOLOGY

The case study methodology was used in this study. The data collected for use in this study was collected from one private University in Kenya. The design of the study utilized qualitative and quantitative approaches to collect the data. Semi-structure interviews were used to extract data, and questionnaire was designed for the same purpose. To ensure complete coverage of the target teams, the Director in charge of online learning, the Heads of respective teaching departments, the IT team, teaching staff, faculty administrators, the head of the library, the registrar were interviewed. The survey was administered online using Google Forms and focused on the implementers of the blended learning. The main focus was on what the users perceived to be critical in the successful implementation of blended learning. Users were allowed to respond to areas where they felt involved, such as in planning, designing equipping, training, teaching and assessment of the learners. The questionnaire was 3 pages long and comprised of 28 questions with a mix of open ended and multiple response questions, with some asking for further explanations to allow drilling down. The original tool was piloted with 2 heads of departments and 2 teaching staff and then fine-tuned to remove ambiguity, then finalized for distribution. Participants were given 3 days to complete and return the survey. Out of the 142 participants approached via email, 92 responded, amounting to 64% response rate. The data was then cleaned and analyzed.

3.1. The Case Study Institution

The case study institution was a private university in Kenya located in in Kiambu County which had started implementing blended learning in January 2020 just before COVID struck, and had to accelerate the adoption in March 2020 to deal with the emergency closure of the Universities occasioned by the Pandemic. The University is now using blended learning and has just recently gotten all its programmes accredited by the local regulator, the Commission for University Education (CUE) to offer Odell and blended

courses. The university has a fully-fledged digital school and offers 12 undergraduate degree programmes, one Masters programme and a number of diploma and certificate programmes. There is a main campus and 2 learning centers. With a student population of over 6000 and a staff complement of 230 administrative and teaching staff, the main programmes include ICT, business, media studies, education, hospitality and international relations. Before the implementation of the Blended learning, the university was using technology to teach but at a much lower scale, focusing on common courses only.

3.2 Blended Learning at the Case Study Institution

Blended learning implementation began with needs analysis after many queries from learners on the possibility of them studying from home. A founder department was set up with skeleton staff who formed a committee with membership drawn from ICT, teaching departments and the finance and planning units. They embarked on benchmarking with global and local institutions and reference to the local ODEL standard to set up the requisite policies, the management structure, identifying suitable courses for blending, suitable Learning management system and other supporting tools, digital resources for the library, training faculty and students and developing modules as well as digitalizing content. They also had to evaluate the best easement and methods for the learners, and how to monitor teaching and learning for effectiveness.

The first step was to develop policies and procedures on blended learning. This involved looking at the curriculum, deciding which courses can be face to face, online or blended, and the best approach for each content. The requisite library resources and the ICT for mode and content was identified. They then trained faculty on how to teach and examine on blended mode. The institution settled on Moodle as the main Learning management system, largely due to its open source nature which made it easier to access and to customize. The LMS was hosted by an offshore company but later moved to the local NREN. To ensure that only accredited curriculum was used, the faculty developed modules that could be used in both face to face modes and online teaching. They are currently in the process of digitizing the same.

The online material was then loaded into the LMS and the test phase began. The piloting was done using 2 common university courses, Communication skills and Health and wellness, before the same being escalated to other University courses. The University has been reviewing its offering on regular basis, with most of the focus being on upgrading the LMS and the resources such as the bandwidth, the devices in use and the digital resources, the policies in place and training both staff and students. It is now generally accepted that the programmes run on a blended mode, and the timetable has been adjusted to reflect the same. The concept of blended learning is now fully entrenched in the University's 2022-2031 Strategic Plan.

4. FINDINGS AND DISCUSSIONS

Of the 142 participants approached, a total of 92 responses were received as follows: 2 from the library, 12 from the digital school, 3 from the ICT department, 6 from faculty

management, 58 teaching staff and 11 finance and administration officers. Since most of the questions were open ended, the responses were analyzed and any concern that was raised by at least two respondents was considered relevant. The questions were grouped according to a). Curriculum, faculty and student's issues b). ICT Infrastructure c). Library and Digital Resources and d). Organizational affordances. The respondents were expected to highlight the major issues that hindered or led to successful implementation of blended learning, and what areas of improvement they would want to see in the process.

4.1 Curriculum, Faculty and Student Affordances

On the curriculum, faculty and student issues, Table 1 below outlines the major concerns to be addressed for successful Blended learning to occur. This section was important since for teaching to take place, you need the learners, a basic curriculum or course of study and the faculty to provide the teaching and ensure that the learning outcomes are met. Questions lingered on what was the most important aspect for the Learning Outcomes to be achieved.

Table 1: Curriculum/ faculty and students' issues

Common Areas	Frequency
Existence of approved blended curriculum	55
Availability of current and relevant content	3
Ease of teaching practical subjects	5
Currency, relevance and frequency of faculty training	53
Availability of instructional designers	25
Specific guidelines for Blended delivery	19
Quality and security of exams	75
Mechanisms for monitoring teaching and learning	18
Provision for giving feedback to students	52
Lecturer evaluation mechanisms	34
Diversity of examination modes and assessments	39
Authentication of learners in blended mode	73
Orientation and training of students	65
Integrity of examinations in blended mode	83

The issues of the curriculum, the authentication of learners, training and orientation of both faculty and students and feedback seemed to be of high concerns amongst the respondents

4.2. ICT Infrastructure

Blended learning requires a mix of face to face and technological infrastructure, with the ICT being the main differentiating factor. Questions lingered on what the users thought was critical for them to deliver the online aspect of the blended mode.

Table 2 below outlines the major issues that the users raised as necessities related to ICT infrastructure.

Table 2: ICT infrastructure Affordances

Common Areas	Frequency
Existence of Core ICT Infrastructure such as servers and PCs	18
Access to a suitable Learning Management System	54
Usability and interoperability of the LMS	5
LMS support for research and project supervision	53
Ability to export and share data in different formats	25
Ability to download content and read and print offline	19
Availability of Antiplagiarism software for online assignments	75
Ability to track students in the online mode	18
Linkage of the LMS, the ERP and the website	52
Students registration and attendance tracking for the online mode	34
Reliable and affordable internet access	39
Ease of changeover between face to face and online modes	73
Security of data and records stored in both physical and online modes	65
Clarity of the interface between face to face and online modes	83

Amongst the biggest concerns was the LMS, the interface, ease of changeover and the security of the system as well as the overall integrity of the process as indicated by the concerns on availability of a suitable anti-plagiarism software.

4.3. Library and Digital Resources

In a face to face establishment, the library is easily accessible physically and users can borrow both physical and digital resources. The questions in this section lingered on what and how users access additional and supplementary resources remotely. The issues of library and digital resources for remote access are highlighted in table 3 below.

Table 3: Library and digital resources affordances

Common Areas	Frequency
Availability of E-books and respective physical books	92
Ease of access and reliability of remote library access	3
Trained library staff to support faculty and students for online access	90
Training services for staff and students	53
Active links to online courses	25
Access to other libraries and data bases	19

The respondents were largely concerned about training of both library staff and the users as well as availability of the resources remotely and physically.

4.4 Organizational Issues

The management is expected to provide organizational support and all other resources to support the faculty and the students. The questions asked here were concerned with the kind of support that users expected from the University to offer blended learning. The critical issues are identified in table 4 below.

Table 4: Institutional support and management issues

Common Areas	Frequency
Existence of a functional unit to manage blended teaching	18
Availability of policies on pedagogy, privacy, research and training	67
Policies on intellectual property and copyrights	16
Mechanism for vetting modules for online mode	53
Clear guidelines on recruitment and training of blended faculty	54
Specific guidelines and procedures for blended teaching and exams	88
Staff and students handbook on blended teaching	75
Mechanisms for monitoring teaching and learning	56
Marketing plans for blended teaching	52
Needs assessments and catering for special needs learners	34
Financial feasibility and viability	54
Acquisition of devices for staff and students	73
Budgetary allocation for blended learning	
Integrity of examinations in	

blended mode	88
	83

This section received the highest frequencies across the questions, indicating that users expected the management to play a critical role in the success of blended learning, with support expected in diverse areas ranging from the budget to recruitment to resources and security.

5. CONCLUSIONS AND RECOMMENDATIONS

The respondents identified several factors that are critical for successful blended learning implementation. If an institution can afford to address these issues, then the whole process will be beneficial to all the stake holders from students to faculty to management to the stakeholders. Careful analysis of the findings yields five affordances:

The institutional and organizational affordances address the planning for blended learning, the financial viability, human resource availability. the feasibility studies, benchmarking and availability of resources such as studios to support both modes, the budgetary allocation and the collaborations and partnerships since one organization is not able to supply all these together. A supportive environment with clear policies and guidelines is identified as key element of this organizational affordance. This supports Rasheed, Kamsin & Abdullah (2020) who pick out challenges of the online component of blended learning.

Academic affordances have to do with the content/curriculum, the students and the faculty. This requires that there is a well-developed curriculum that can be offered in both online and face to face modes. The institution has to select the mode of delivery for each type of content and decide on the percentage of blending. This requires the course design to be well articulated and quality assurance mechanisms to be put in place. This is concurrence with Jean-Francois (2013) and also Iskander (2008) who alluded to that fact that the design of the curriculum should be flexible enough to allow various modes.

Pedagogical affordances refer to the actual mode of delivery and how to get feedback from students, how to evaluate the course and ensure the achievement of learning outcomes on the blended mode. For example, if a course has both face to face and online elements, there should be clear guidelines on the type of examination that will be offered for which instance. This affordance demands a lot of training for both staff and students as well as the support teams, and also includes elements of academic advising. This agrees with Khan (2005) and the issues highlighted in his Octagon.

Technological affordances refer to the availability of the requisite technology including the servers, the hosting, the LMS and other tools for teaching and simulation, including videoconferencing and virtual labs where needed. Some of the technology is not used for online teaching but the face to face classes; projectors and presentation software fall in this category. Monitoring of teaching and reliable internet connectivity are some other technological requirements, as well as ways of checking for plagiarism and enrolling students for the online mode, in

agreement with Previtali & Scarozza (2019) and Park & Shea (2020).

Digital resource affordances refer to the library to supplement the physical books for the online mode. Remote access software and links to relevant databases, plus the training on how to use these are also elements that will make blended learning to be a success.

The five affordances grouped as organizational, academic, pedagogical, technological and digital resources are crucial for any institution to succeed in blended learning implementation. It is good to note that all these affordances are interrelated, and training and ICT cut across them. It would be futile to develop a good curriculum and buy the requisite technology without training both students and staff, or have a good curriculum and trained faculty without the requisite technological resources.

This study did not talk to the main recipients of the teaching, that is, the students, and perhaps future case studies can incorporate the learners for a deeper perspective on the affordances. Policy makers can refer to this case study when rolling out or reviewing a blended approach.

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International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 118-122, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1005

Baseline Survey on Software and Tools for Odel and Digital Learning during and Post Covid 19 in Selected Universities in Kenya

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Abstract: One the mitigating measures adopted against the spread of COVID-19 was closure of business, suspension of face to face learning in institution of learning in Kenya and cancellation of international flights worldwide. There was also enforced locked down within highly infected areas. To survive educational institutions adopted mainly online/digital learning. In this paper we provide findings on a survey conducted in selected eleven universities in Kenya on the status of the soft wares and tools that facilitate online/ digital learning. The finding indicate that even though the universities had adopted blended learning the soft wares and tools are still a challenge. The Paper recommends the need of the institutions to enhance the acquisitions of tools and soft wares for an enhanced digital learning and inclusion..

Keywords: Software, Tools, Digital learning, Digital Inclusion, Covid-19

1. INTRODUCTION

in March 2020 the face to face education system in Kenya and in most parts of world was brought to halt as mitigation measure against the spread COVID-19 pandemic(E.I. Omwenga ,P.M.F. Mbithi, J.N. Muthama ,J.M.Chone[1]. The disruption of education calendar, put a stake graduation and progression of students. For most Universities student fees are the main source income to fund University activities, the disruption of student on campus stay resulted in a financial strain to the Universities. Digital and online learning then became the silver bullet towards these problems. The paper then sought to carry out a survey on status of softwares and tools required in Digital and online learning sampled eleven Kenyan Universities.

2. METHODOLOGY

A research methodology is guide on methods that will be used to collect Data, analyze and interpret the findings. In every research the need for good quality Data cannot be overemphasized if for output to have integrity. Surveys which are manual and electronic are most common mode of data collection. Three major methods of collecting survey data electronically are computer administered surveys, electronic mail surveys, and web surveys (M. S. Nayak,, K.A. Narayan, [2]. For this research the survey research design was adopted, where a set electronic mail **questionnaire forwarded into the** participating Universities. This mode allowed research to abide with COVID_ 19 protocols. Descriptive statistics were used in analysis of the data. Data was presented using bar charts and pie charts

3. RELATED STUDIES

Mbithi P.M.F. and Omwenga E.[3] did submit a proposal how Universities could be supported to mitigate the Challenges of Covid-19, Especially in Areas Of Digital Learning (ICT Infrastructure. They sought funding, on behave of 11 Universities from the African development bank to bridge identified gaps in present education systems.

In Position paper on ICT Infrastructure Development Funding Support as a Strategy for Public Universities overcome the Challenges Of Covid-19 by G.N. Chemining, S.M.Mbuguah, B.M Sanda, M.A.Elimi , A.H. Mohamed A.A.Hared, C. Oduor. D.N.Kamsingi [4], was submitted to the Kenya School of Government. They proposed a marshal plan to fund ICT infrastructure. They aver that forced closure of the universities resulted in universities being pushed into online learning without adequate notice and preparation They suggest that universities especially public university are experiencing reduced capitation from exchequer and reduced number of

students, leading to the universities becoming insolvent. They vouch for Government of Kenya find a funding to university to improve on ICT.

In a study carried out by Ngwacho A.G.[5] on impact COVID-19 Globally, and in Kenya, it was found out that economic growth has been and will be negatively affected by COVID-19 whose negative effect was felt by the poor, vulnerable and marginalized households who rely on informal employment and businesses to fend for their children. The study infers that the ability to finance school related expenditure such as school kits, meals, learning materials has been s compromised by the pandemic. The study concludes that the Government adoption of remote teaching to support distance learning and online education delivered through ICT will increase the digital divide to , leaners from poor, vulnerable and marginalized household.

In a study carried out by Kathula.D.N[6] on the effects of Covid-19 students, teachers and parents It was found out that parents and teachers especially in private schools lost their jobs or source of livelihoods. That most of the students were not able to access online learning due to lack of electricity, lack of learning materials and some were even forced to relocate to the country side. The study hence concludes that as a result of the challenges presented by the coronavirus and the likely impact of future pandemics the government's ability to ensure continuation of learning will depend on the ability to swiftly harness available technology, provide adequate infrastructure and mobilize stakeholders to prepare alternative learning programmes

On a study carried out by Lugonzo, H[7]. on online education and distance learning which has been implemented by the Kenyan government through the Ministry of Education it was found out that it does not allow learners to have a personal relationship and intimate interaction with the online teacher. Also online teaching do not favor such learners as most of them do not have access to mediums like smartphone, internet connectivity, computers, televisions, radios, among others. The study posits this has widened inequality in access to relevant quality education by such disadvantaged learners. The study suggests the need a strategy to determine mitigation measures (

A study was carried out carried out by E.I. Omwenga ,etal.(2021).… on the perception of impact of COVID-19 pandemic on diverse aspect of teaching and learning in Kenya. The study found out that Students were concerned with internet connectivity, computing devices and electrical power. While teaching staff were mainly concerned with access to the teaching resources, conducting online teaching, capacity to handle the online mode of teaching, devices and eContent development. The study infers that the pandemic has exposed the shortcomings of the current higher education system and the need for enhanced policy formulation and implementation on digital infrastructure to adapt to the rapidly changing education ecosystem of the world

Mbuguah SM, Njuguna A. Makokha J. and Njoki C.[8] have also written a paper on baseline survey baseline survey on an ICT infrastructure for Odel and digital learning during and post COVID 19: The paper concentrated more on hardware aspect and conclude that most institution are lacking the necessary infrastructure and recommending that Government should move in to fund the financially challenged institutions.

4. FINDING AND DISCUSSION

In this section an analysis of feedback of each question is presented and discussed.

4.1 Findings

(I) On the question which mode is used to offer your courses? All the respondent said Blended =16. The implication is that each of sampled university and adopted some form of digital learning.

(II) All the 16 participants' respondent with a yes to the Question Does your university have a learning management systems? This means all university geared towards digital learning.

(III) On the question on whether university has Student information system. The response by all the participant was Yes. The implication is that university are e-ready.

(IV) The response to question does your university have the Content management systems? The response was Yes = 15, No = 0 and Blank = 1. For the response it means that the university are in a place to create content suitable for digital learning.

(V) On the question on whether your university has the Plagiarism detection software? The response was Yes = 14, N0 =1 and Blank =1. This implies that universities are set to monitor content of student work to ensure that it can stand the test of integrity and ensure quality of the students work.

(VI) On question does your university have the Software Exam proctoring software? The response was No= 10, Yes =5 and Blank= 1. The response to this means that most universities have challenge offering online examination. There is need to facilitate them otherwise the university have to result to blended learning.

(VII) On the question does your university have Monitoring and Quality assessment tools? The response Yes = 12, NO = 3 and Blank =1. The implication of the result is that most of universities take quality of their program and graduates seriously. However there room for improvement.

(VIII) On the question does your university have the Helpline for e-learning? The response was NO =4, YESs =11 and Blank =1. Most of the Universities are set to assist their students remotely. But all university should have a help system to ensure that digital learning is friendly and effective.

(IX) On the question on whether these systems are integrated?. The response was Yes =7,No =8

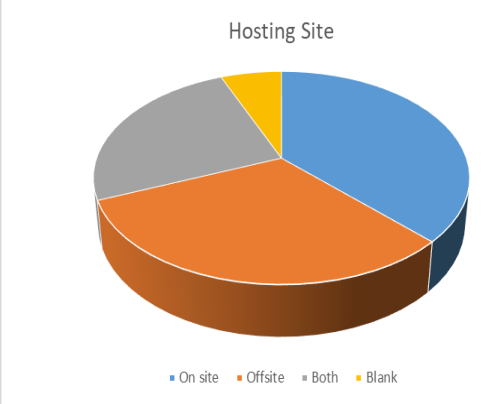
International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 118-122, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1005

andBlank=1. The implication is that 50% have system that are not integrated which means hat systems cannot seamlessly interact, this is hindrance to effective digital learning.

(X) On the question on whether monitoring of Lecturers and student engagement on the LMS is done? The response was Yes =13, No =2 and Blank =1. From the responses most of the university keep in touch with progress of students and execution of learning process.

(XI) On the question which LMS do you use in your institution for e-Learning? The response was Moodle = 13, Google classroom =1 and Blank = 1. From the responses it appears that Moodle is the most popular LMS

(XII) On the question where these systems are hosted? The response was On site = 6(38%), Offsite = 5(31%) , Both = 4(25%) and blank =1(6%). From the responses it appears there is no preferred site of hosting the system.

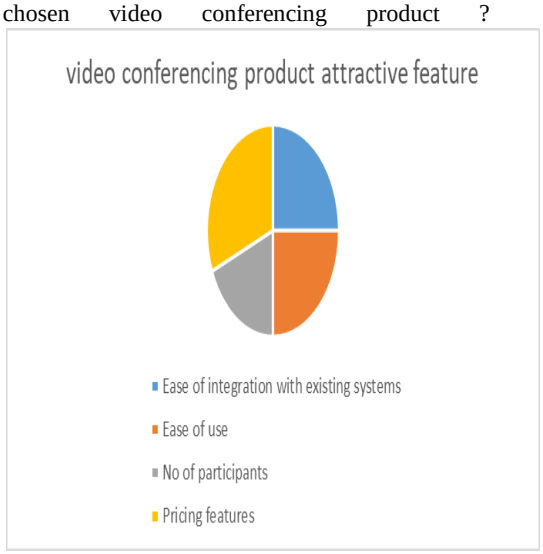


(XIII) On the question on whether the University had a premium video conferencing account(s)? The response was No =7 and yes=9. The response to this question means there is still room for improvements as far as video conferencing is concerned.

(XIV) On whether teaching staff have access to or have accounts to use Premium video conferencing platforms? The response was Yes =11and N0=5 . Most respondents have premium accounts.

(XV) On which video conferencing tools used by your University? The response was Zoom =11and Google meet = 5. In this case it appears that Zoom is most preferred video conferencing tool.

(XVI) On question of what most attracted you to your chosen video conferencing product ?

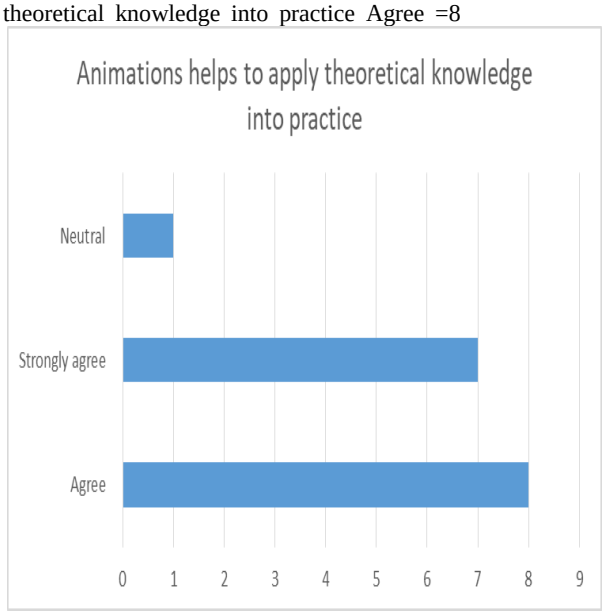


(XVII) Ease of integration with existing systems = 4(25%)
Ease of use = 4(25%)
No of participants = 3(19%)
Pricing features = 5(31%)

From the responses it appears there equally valid reasons for selecting the video conferencing tool but pricing features appear to have a slightly higher impact.

(XVIII) On the question do you use virtual Lab tools for teaching practical lessons? The response was Yes= 4 and NO =12. From the responses then it implies that most university are not ready for virtual labs and hence the labs for now will have to be physical. However there is need for institution use virtual labs.

(XIX) On the extent to which you Strongly Agree/ Agree/ Disagree/ Strongly Disagree /Neutral with the statement Animations helps to apply theoretical knowledge into practice Agree =8



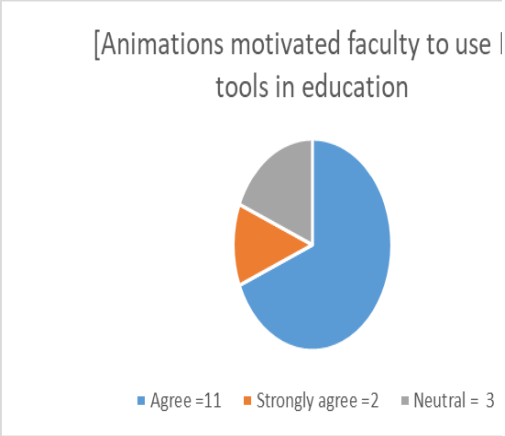
Strongly agree =7

Neutral =1

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 118-122, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1005

From the responses it appears that the respondent consider animation as a valuable tool in digital learning

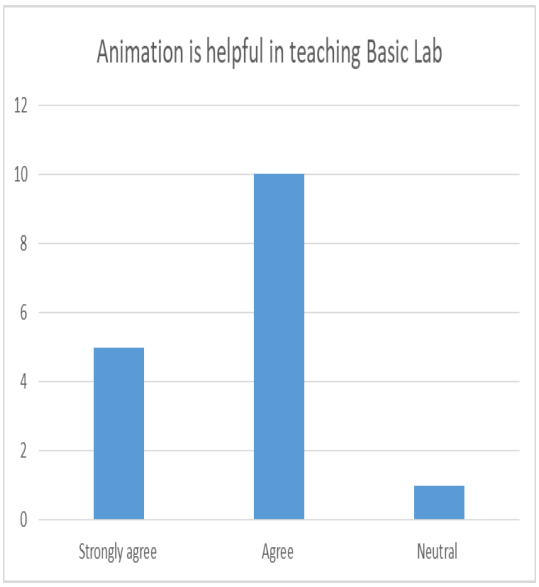
(XX) On the question Please rate the extent to which you strongly Agree/ Agree/ Disagree/ Strongly Disagree /Neutral with the statements Animations motivated faculty to use ICT tools in education. The response was Agree =11(69%), Strongly agree =2(13%) and Neutral = 3(19%)



From the respondent do appreciate use animation motivated staff to use ICT tools.

(XXI) Please rate the extent to which you Strongly Agree/ Agree/ Disagree/ Strongly Disagree /Neutral with the following statements. [Animations is helpful in teaching basic lab techniques easily with standardized protocols and enhance, intensify and motivate

Strongly agree = 5
Agree =10
Neutral = 1



online online

Most of staff agree that animation can help in teaching basic labs

4.2 Discussion

From the findings it appears that most of the selected Universities have the necessary basic soft wares and tools to engage in digital learning. The main drawback is lack of an examination software to conduct online examination. This means for most universities examinations will have to be physical, in order to ensure the quality and integrity of examination process. This is a challenge. Another observation is that most universities were not exposed to virtual labs. Hence the Labs will have to be physical which is a challenge during lockdown. However, most staff are well aware that even animation could lead to transfer of knowledge as would be the case of a live experiment. To enhance, efficiency the systems should be integrated.

5. CONCLUSION AND RECOMMENDATIONS

The researchers do conclude the most of the sampled universities to have the appropriate softwares and tools to facilitate digital learning and are involved in blended learning. The sampled universities adopted fast to the learning challenges due to COVID-19 pandemic. Even though the transition and graduations of student was delayed but it did happen. Most of the universities adopted blended learning as the new normal. However there challenges in conduction of online examination and laboratories. The systems are also not fully integrated.

The researchers do recommend that universities find strategies of acquiring Exam proctoring software which will assure the quality and integrity online examination. There is need for university to invest in virtual labs to allow practical's to continue even during lockdown. They will enhance transition and graduation of students. There is also need for integrated system to allow effective and efficient seamless flow of the various soft wares available.

6. ACKNOWLEDGMENTS

This study was done carried out education for Education for Sustainable Development in Africa (ESDA) phase 2 project supported by the African Development Bank (AfDB). We appreciate lead persons in this project Prof. Peter Mbithi and Prof Muthama of University Nairobi and Prof Elijah Omwenga of University of Kabianga.. We thank the eleven participating Universities in the consortium and their representatives in the project. These representatives coordinated the data collection exercise and we single them out, with gratitude, within their respective Universities. For Daystar University we had Dr. Caroline Ayuya, Mr. Samson Mburu and Dr. Sylvia Tuikong; Dedan Kimathi University of Technology: Prof. G K Muthakia, Dr. John M. Wandeto, Mr. Muchiri Michael Njoki and Dr. Moses Ollengo, Garissa University: Dr. Aden Ali Abdi and Mr. Felix Wasike, Jomo Kenyatta University of Agriculture and Technology: Prof.

Urbanus N. Mutwiwa, Prof Rebecca W. Waihenya, Prof. Stephen Kimani and Dr. Kipchumba Cherono, Kenyatta University: Dr John Muriuki and Anthony Mbaabu, , Pwani University: Dr. Leornard Kiti Alii, Dr. Fred Namasaka and Dr. Rose Kigathi, South Eastern Kenya University: Dr. Andrew Omala, Kim Musyoka Musila and Dr. David Musembi, University of Kabianga: Dr. Patrick Bii andMr. Geoffrey Sowek, University of Nairobi: Prof. Christopher Gakuu and Mr. Paul Kariuki

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International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1006

Design and Implementation of a Web Based Leave Management System

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Abstract: In current era of net-centric computing, the availability of a web-based leave management system has become an essential and indispensable tool for any organization and corporation. It can track and manage a variety of employee leaves, as well as process requests for time off for employees. However, there were issues raised concerning inefficiency, downtime, and delays in the processing and approval of leave requests in the human resources departments of corporations and agencies. This paper explains why it is necessary to develop a system that uses web-technologies to eliminate bottlenecks in getting leave approved on time. This paper used a qualitative research approach to gather insights and familiarity with what is in existence so that more research can be done. Data was gathered through interviews, scenario generation using stakeholders' and participants' experiential narratives, and analysis of present processes and structures. The development approach followed a software development methodology. A web-based leave management system (WBLMS) was designed using Unified Modelling Language (UML) tools with its database designed using SQLite, implemented using web technologies such as HTML, CSS, Python Programming language and its Django framework and evaluated using DeLeon and McLean Information theory. The outcome of the system evaluation revealed a positive result. Upon the use of the system developed, the response from respondents yielded 76.67% satisfaction rate. This is indicative of the fact that when users (junior and senior staff) use the leave system, it was considered acceptable and good enough to achieve or meet the requirement specified). The system also yielded 81.67% accuracy and gave 81.67% ease of use. The paper concluded that a proposed leave system developed enhance user satisfaction, increase productivity and ensure efficiency as well as the effectiveness of the process and employees while reducing the time taken in processing leave application.

Keywords: Leave; Efficiency; Effectiveness; Web-Technologies; Information Systems; Communication; Management; Human Resource.

1. INTRODUCTION

Human resource management is concerned with the process of dealing with people at work. Human resource management (HRM) is the process of connecting individuals with organizations in order to assist them achieve their objectives. Human resource management (HRM) in organizations and enterprises throughout the world has become a vital arm of any firm in the quest for ever-increasing human productivity. This is due to the fact that their responsibilities include concerns such as remuneration, performance, development, safety, wellness, benefits, employee motivation, and training [1].

With the advancement and improvement in Information and Communication Technology (ICT) in recent years, there has been a paradigm change in the understanding of the role of ICT in human resource management. Several organizations and enterprises have realized the growing relevance of using IT to maximize the effectiveness of their HR responsibilities. This takes the form of electronic human resource management [2, 3), which relies on cutting-edge technology ranging from internet-based human resource management information systems (HRIS) to shared and common intranet and enterprise portals.

As a result, HRMIS can be defined as a system that allows you to keep track of your personnel and their information. In fact, information technology (IT) and human resource management have a wide range of effects on one another, so human resource personnel should be allowed to adopt technological advancements that allow for the re-engineering of human resource action, be prepared to maintain an organization and work project caused by technology, and be able to maintain an effective administrative atmosphere for innovation and knowledge-driven organizations.

Within the field of ICT, the use of electronic or online Web-based Leave Management System (WBLMS) is to ensure that standard effective management and productivity (Physical and mental) of employees in the organization are maintained. Therefore, there is a need to develop a system that reduces the delay in granting leave application. The need for a web-based system is therefore based on the fact that there is a large volume of paperwork that is processed manually and takes a long time to process and that the application needs to be reduced. This does indeed cause a great deal of damage or danger to the to the overall productivity and efficiency of employees in the organization. There is a need to develop a system that reduces the delay encountered in the granting of leave applications.

Therefore, developing a WBLMS will help reduce the downtime as well as the paperwork and manual record keeping information about the worker quicker with a quick analysis of the problems. The main aim of this study is to build a user-friendly web-based/online integrated public service leave management system, which is focused on a functional leave management system in the public service domain. In this paper, attention is focused only on public agencies using the African Regional Center for Space

Science and Technology Education in English (ARCSSTEE), Nigeria as our case study.

A Web-based Leave Management System (WBLMS) is described as a Human Resource (HR) software web application that is designed with the purpose of managing human capital, leave request, procedures and records. In other words, it is seen to be a useful HR subsidiary system set aside for overseeing employee leave matters. Leave Management System (LMS) is simple to understand, easy to use and more convenient to implement.

The main aim of LMS development for the public sector is to shift away from a conventional model to a more reliable and effective level of leave management [4, 5]. Nowadays, the current way of managing leave request is paper-based for many public organizations in Nigeria.

Studies has shown that the manual leave management approach utilized by most public sector firms has proven to be inefficient and inconvenient. Anyone who has applied for leave understands how unpleasant and tiresome it is to write and submit an application and then wait for it to be approved as the hard copy moves up and down the approval chain. With its capabilities, a digital leave management web application will eliminate physical movements and allow HR to have a bird's eye perspective of the organization's leave status. This will undoubtedly aid in the efficient disposition of leave-related duties such as easy application of leave request, easy tracking of employees on leave, coordinated leave workflow process, reduced accumulation of leave forms, structured data presentation for report analysis generation and quick approvals in the pursuit of a long-term, redundancy-free system.

Public service organizations are known for large human capital workforce. Therefore, leave management remains a vital area to be considered in terms of proper leave records management. The much-desired new public management system in Nigeria can only be achieved if we begin to adopt more implementation of management information systems in eliminating redundant operations.

2. LITERATURE REVIEW

The relevance of information systems within enterprises has increased as a result of the growth of the Internet, globalization of trade, and the rise of information economies. Researchers and practitioners must understand how information technologies impact the corporate world. Management information systems (MIS) is a field of study that focuses on the use of computer-based information systems in businesses and government agencies. It first emerged in the 1970s [6].

An information System (IS) is defined by [7] as an interconnected set of interactions that share information and are capable of integrating into a common information unit. The goal of Information System Theory is to create a link between the formalistic approach of general system theory and the world of information and information technology. They must retrieve information, store it, access it, convert/change it, transport/transmit/communicate it, and process it in order to generate the intended information service [8]. It turns out that conceptually separating retrieval and processing systems is difficult from this standpoint. However, an IS strategy must be adaptable to both functions. Any data processing system's job is to offer data to aid in decision-making, problem-solving, or operational tasks. As a result, such a system can only be truly comprehended as an information system. The information aspect understands that the data's main purpose is to provide individuals with information.

Information systems have been existing for more than three decades, according to [9]. In this regard, various types of Information Systems are accessible for a variety of purposes. Currently, the types of information systems available are Transaction Processing, Process Control, Office Automation, Management Information Systems, Decision Support system, Executive Support System, Expert systems, knowledge Management system, Strategic Information and Functional-based Information system.
Functional-based information systems assist an organization's operational and management applications. Finance and Accounting Information Systems, Manufacturing and Production Systems, Sales and Marketing Systems, and Human Resource Management Information Systems (HRMIS) are all examples of information systems

Today, the growth of organizations is driven by the availability of a large amount of information. The Human Resources office in organizations helps to the public service's organizational purpose by supporting informed employee benefit decision-making by delivering accurate, timely, and useable data However, with the rise in globalization, it has become important to identify less challenging and more convenient systems to help organizations in managing their data for efficiency and efficiency.

[10] opined that the efficiency and effectiveness of activities within an organization can be improved by developing computer-based Information Systems across every functional unit. Out of the many advantages that workers have, leave is one of the most important functions carried out by the HRM.

Leave is defined as an officer's approved absence from duty for a specified period of time, according to the public service rule of 2008. The act of taking time off work cannot be overlooked or dismissed, since every employee has the right and opportunity to request time off to rest or attend to personal matters outside of the workplace. There are various types of leave and reasons why employees want time off from work. The availability of various types of leave that are commonly acknowledged in Nigerian public sector organizations include maternity, medical, study, Sabbatical, proportionate, annual, casual, deferred leave, leave for compulsory and non-compulsory examination, leave of permanent invalidation and others alike, is critical to workers' physical and emotional health. If appropriately constructed, it can have the desired positive influence on workplace health and safety, as well as boost productivity and performance.

The Human Resource Management Information System (HRMIS) which is an aspect of MIS is one of the vital digital solutions human resource personnel uses in managing most of their operations. Therefore, Leave Management System (LMS) is a human resource sub-system or under HRMIS dedicated to collecting, disseminating, storing and managing employee leave applications.

Given the understanding of HRMIS, it can be deduced that a web-based LMS is a Human Resource (HR) software web application that is designed to manage human capital leave requests, procedures and records. It is captured to be a useful HR subsidiary system segregated for managing employee leave matters. Employees use LMS to request permission for leave by filling their desired dates for management approval (Singh, 2016). Other subsystems used are Payroll System, Employee Attendance System and Employee Management System like ADP, Peoplesoft and others to mention a few [11]. LMS is simple to understand, easy to use and more convenient to implement within a workspace environment. One of the many advantages of designing a Web-based LMS for the public sector is to transcend from a traditional conventional system to a more reliable and effective system [4].

In general, the Nigerian public service sector has fallen short of expectations in terms of building an effective ICT and Management Information System-based applications to improve the overall operational performance of the nation's public service. As the zenith of the Nigerian public sector, federal ministries provide administrative structures for the implementation of government programs, plans, and policies.

According [12], the structure and operations of ministries and parastatals, particularly federal, reveal that senior managers engage in traditional management operations and make key choices in the course of their regular duties. In this sense, there is unquestionably a pressing need for ministries to implement effective MIS. As a result, the use of MIS technology represents a new public management agenda aimed at reforming the public and civil service sectors. To improve the character of the civil service operation, this management promotes efficiency, effectiveness, and performance [13]. With the advent of globalization, however, it has become critical to identify less difficult and more convenient technologies to assist firms in managing their operations and data for efficiency and effectiveness.

The Nigeria Government requires a departure from the traditional method of administration and the urgent need for a reviewed public sector to propel the government to its quest for sustainable, socio-economic, political and technological development [14]. The drive towards technological advancement in public service can be achieved using IS. As a result, it is clear that in order to carry out these functions effectively, public service organizations need IS to address recurring issues like poor information management, inaccuracies, data non-availability, and a lack of information for monitoring, regulating, communicating, and controlling public service operations [15].

2.1 RELATED WORK

Some existing relevant systems are examined in relation to this study to determine how our proposed d system will be developed. For instance, Mobile HRM online leave management system, Student leave management system, University and other short academic leave management system, Web based staff management system, and an E-Leave management system for the banking sector are some of the systems available.

[16] in their work demonstrated a desktop-based payroll management system. The architecture of the proposed system is a three-tier, which was designed using Software development lifecycle methodology and built with technologies such as HTML, CSS, and JQuery for the frontend, C#, ASP.net for the backend, and JSON and Ajax for data parsing. The outcome revealed that the proposed system is more efficient since it provides a user-friendly environment, reduces manual calculation errors, and improves security. This study shows relevance to the task of developing a leave management system, thus providing tools and technologies needed to construct the system.

[17] investigated the issue of students being unable to submit their leave applications. The system developed was created to keep track of a student's attendance, records as well as allow students to submit their leave requests online rather than using a manual approach that relies on pen and paper A real method Group technique was used by the authors. The brainstorming process entails getting into groups and coming up with ideas. The authors created a student leave management system to solve the issue of attendance using Java programming language and cascading Stylesheet (CS) for Android. The outcome demonstrated that the developed approach was unique and effective.

[18] presented a leave and payroll management system to reduce manual work and to overcome the problem of time management. In an attempt to achieve the aim, the authors developed a web portal system that provides the employees of an organization with an online platform to view their leave history and apply for leave. The payroll system was implemented using VB.net as frontend and Microsoft Access 2007 SQL server 2008 as the backend. However, the system developed is desktop-based and could allow users to use it dynamically anywhere.

[19] in his paper addressed the issue of data loss, particularly when data is not backed up on a regular basis. To address the issue, the author created a user-friendly employee leave database management system that allows personnel information to be accessed throughout the business organization for decision-making purposes. The software was created by automating the submission of leave requests and approvals. In addition, the system's data was gathered through interviews, questionnaires, and observations. The system was developed using Entity Relationship Diagram, Data Flow Diagram, and context diagram with a distributed based architecture and a centralized database utilizing MS-SQL server. The system was developed using ASP.net web technologies after following through the steps of the water fall model; and tested with a systematic testing methodology that included exercising all internal data structures to ensure validity. According to the findings of the research. The study concluded that the organization's decision-making process was considerably aided by speedy information processing, as data collecting from computer-based information takes much less time than a manual system.

[4] addressed the delay in the manual filling of leave form and waiting to get higher officials' signature. To automate the LMS, which is central to the organization activities, the authors presented a "MOBILE HRM LMS". The Mobile HRM LMS is an intranet-based application that was developed to improve the leaves segment and can be accessed throughout the organization or a department. The

main aim of building the mobile HRM LMS is to reduce time spent on leave processing. The proposed system was designed using Data Flow Diagrams (DFD) and implemented using PHP programming. The result showed that there is no necessity for manual filling of leave form and wait to get approvals. The result indicated that the application developed allows the staff of the organization to view the previous leave applied by them and its ease of use thereby, reducing time.

[20] investigated the flaws in the organization's usage of a traditional way of personnel records management and administration. The authors presented a web-based Staff Management System (SMS) to bring about transparency, organizational accountability, and allow accurate audits by creating and ensuring SMS records as solid proof as established by [1] and maintains a database of employment status, educational background, staff information, event records, sick and vacation leave credits, and also a database of employee performance [21].
The proposed system is a web-based application developed using the K-means clustering approach. MySQL was used as the database tool, written in PHP and developed using web technology tools such as HTML, JavaScript, CSS, JSP on a LUNA Eclipse Integrated Development Environment with the Tomcat 7.0 Server and implemented using Java programming language. The result indicated that the developed automated system helps in reducing various costs such as manpower, staff information, and work scheduling and performance analysis.

[22] examined the time loss in applying for leave and search for employees' records. management system or personnel information. The authors used the iterative technique as a development process. Similarly, issues about the existing system were discovered, and interviews and consultations with users of the existing system were conducted in order to offer a thorough examination of the system's current operations and structure. The authors identified the requirements for constructing the leave management system in order to handle the challenge, and the system was designed using Data Flow Diagrams (DFD) and Entity Relationship Diagrams (ERD). The designed system was implemented using PHP programming language for user interface design and Structured Query Language for database design. The developed system was system was tested and evaluated. The outcome of the system indicated that there was less downtime or delay in the leave request and approval process. The study concluded that developing a leave management system decreases paperwork and time spent processing files, resulting in increased efficiency and effectiveness.

[23] documents an internship report on leave management system. However only a few features of the system were given due to time constraints, organizational data confidentiality, and resource constraints. [24] created an intranet-based leave management system that can be used by employees within a company. The system can be used to request, authorize, and produce leave reports, but only for intranet-based activities. [25] created a leave and pay roll management system that allows for leave request submission, history viewing, and approval/rejection.

[26] developed an android-based leave management system to handle employee leave requests and approval/rejection in an effective and efficient manner. Although the system is capable of correctly handling employee leave, it is only compatible with Android. As a result, the platform is not suitable for usage as a web application [27] developed a cloud-based staff management information system prototype for African small and medium-sized businesses. The system consists of four key components: leave management, payroll management, employee appraisal, and record management. Despite the fact that the system was supposed to cover every aspect of human resources in African small and medium businesses, only a prototype of the proposed system was produced at the time of this study.

[28] developed an intranet-based student leave management system that automates leave request acceptance and denial. Furthermore, [29] created an algorithm for scheduling leave for academic personnel for the Nigerian university system. The system calculates the personnel mix by rank and the lecture-to-student ratio bbefore providing services.

[30] investigated the difficulty involved in the management of information concerning staff, and the student leaves using the common manual method of leave requests and approvals. The authors developed an android-based Leave management system using software methodology and an Android Software Kit with a user interface module to overcome the prevailing challenges and ensure efficiency and overall performance. The system was built on a three-tier web framework, which included a mobile device, a web server, and a database (also known as presentation, application, and storage) respectively. As a result, an optimal solution for staff and student leave requests, approval, and tracking was created. The authors concluded that the Leave management system application was created to address the issue of time-consuming manual leave applications. It also aided workers and students in applying for leave using the app and receiving approval from higher officials, as well as notifying higher officials when leave is applied for and informing the individual user of their leave status.

[31, 32] developed a simple Employee leave management system for managing staff leave in Higher Education Iinstitutions (HEI). Adamu planned and developed the system by utilizing web-based technologies such as CSS, JS, HTML, and MySQL, and implemented using a three-tier architecture software model. In a similar vein, [32] used the widely known USSD System for Employee Leave Monitoring and Management in Higher Educational Institutions using the same three tier software architecture model employed by Adamu (2020). The system is built with PHP for general programming, MySQL for database management, and the Adobe Dreamweaver CS3 IDE for development on the Windows 7 operating system. The system was hosted locally using the Apache TOMCAT webserver. The result revealed that the two system have 94% convenience and success rate of usage. The system improves staff management, maintains accuracy, and openness, and emphasizes the need for advanced technology to be integrated into employee records and welfare management in higher education. Employees in academic institutions can seek and track their leave at their leisure and in a timely manner using the developed system

Despite this, the public agency known as African Regional Centre for Space Science and Technology Education in English (ARCSSTEE) implements most leave types available in the public service rule [33]. The leave management system of ARCSSTEE is more less a manual

system that uses a book register to monitor leave application process yet not implemented. Here, leave applications are approved by two authorities at the centre: the Head of Department (HOD) and the Director. Leave applications only get approved when they are around, else all leave applications wait till they return which results to unexpected delays in granting leave approvals. Figure 1 and 2 provides a conceptual framework and the flowchart for the leave process that normally occurs when an officer plans to apply for leave. The process starts with the officer and proceeds to the head of department for recommendation. The application needs the director approval before the officer is allowed to proceed on leave. Thereafter, the human resource department conveys the leave approval letter to the applying officer. Yet, the major drawback of the existing systems is that they all focused on information dissipation mainly. None of the existing works explored the use of internet as a tool for ubiquitous data creation, assess, update or deletion.

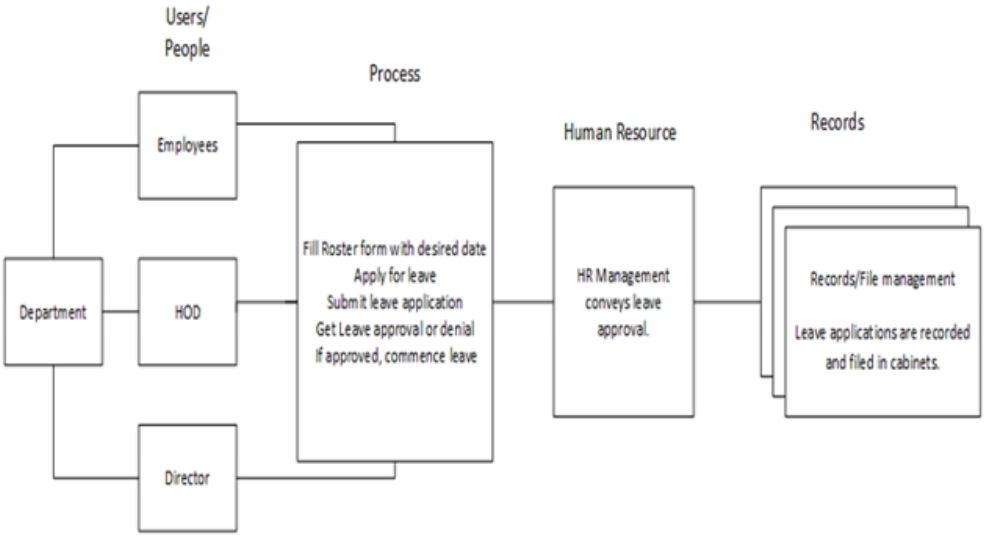

Figure1: Conceptual Design of the existing ARCSSTEE leave system

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1006

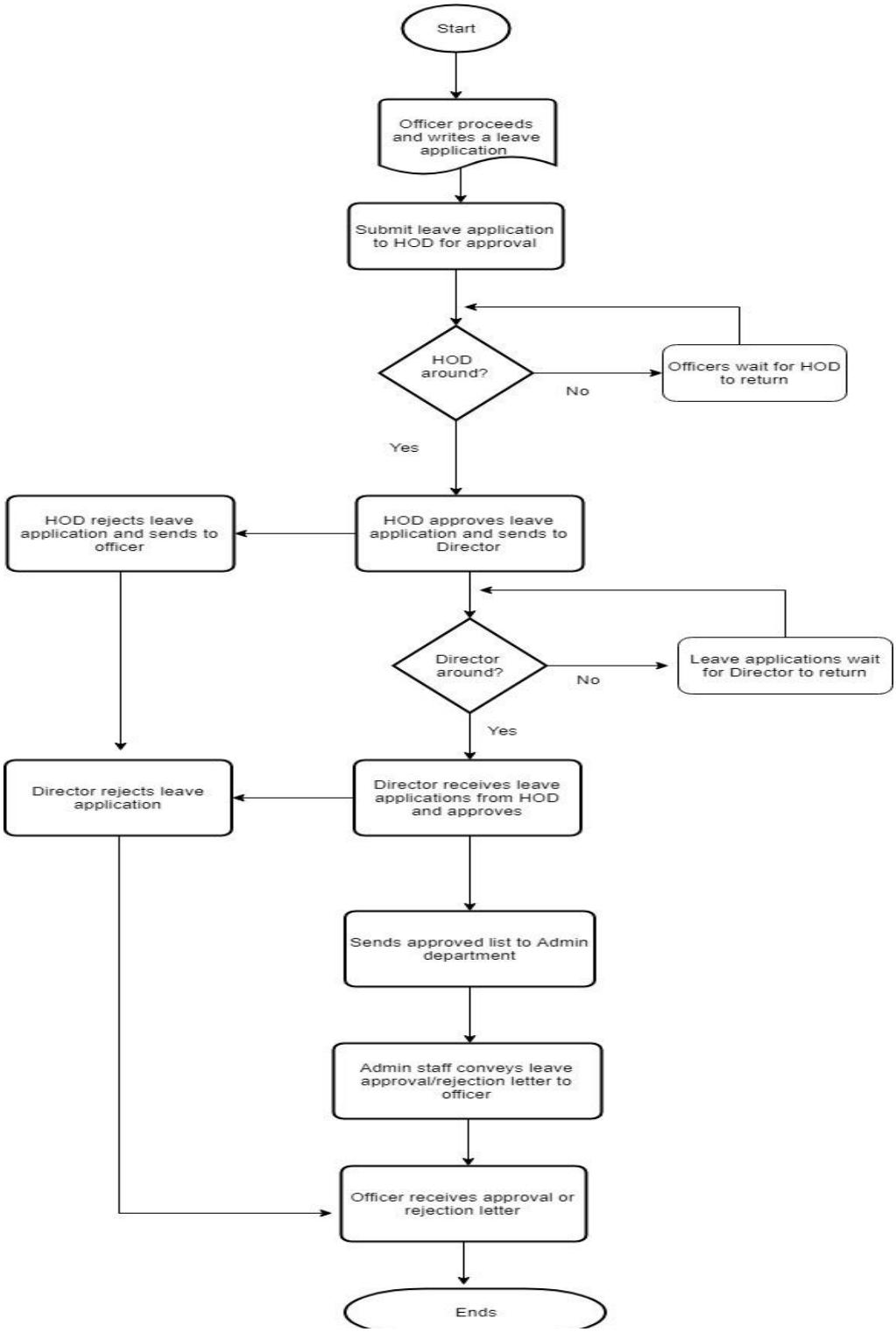

Figure 2. Flowchart describing the leave application process at the public organization

3. METHODOLOGY

The proposed Leave Management system was developed using the Object-Oriented Analysis and Design Methodology (OOADM), which is an approach for designing high-quality Information Systems that combine information technology, people, and data to satisfy business requirements.

The system architecture was designed to gives the ideal representation that describes the structure and views of the system as shown in Figure 3 and 4. The requirements for the system was specified using Use case as depicted in Table 1. The System specifications were designed using Unified Modelling Language (UML) tools namely Use case, Class diagram, Activity diagram, Sequence diagram illustrating the design of the proposed system as shown in Figures 5, 6, 7 and 8 respectively. The use case diagram

describes the system, its corresponding actors that is, the employee, HOD, Director, HR and the Administrator, and the roles the actors perform such as request for leave and granting approvals.

Figure 6 describes the different activities that a user can perform when he logs into a system. The activities include leave request application, views leave history, submit leave application to HOD, HOD approves or declines employee leave applications, HR management consent and approval, and reports generation. The class diagram illustrated in figure 7 presents the different object and classes containing its attributes and methods. The classes represented in the diagram are Leave Request, Employee, Login, HOD, Employee Leave history, HR Administrator and Department. The class diagram provides two visibility types namely public and private. While Figure 8 depict system dynamics by showing the participating objects (classes, components, etc.) in the interaction and the sequence of messages exchanged

The Re-engineered system designed in [33] was implemented using a Python Programming Language with its Web Framework called Django. Django framework uses a Model View Controller (MVC) framework in defining the web applications structure. The Model represent the database model, the View acts as the controller that handles all the functions and what (objects) gets viewed on the front-end and lastly the Template as the static files that is viewed by the user through the user interface. It consists of the client interface, a computer software that offer service to software application (middleware) and database. The graphical user interfaces (front side) was designed and developed using HTML, CSS and JavaScript, while the middleware was designed based on the WGSI web server and the back-end was the SQLite database system. The web browsers present and process the web site, which is the interface for the middleware and data access layer.

The leave management system of the case-study employed the use of a qualitative research approach to gain insights and familiarity with what exist to allow further study. Interviews, scenario-generation from stakeholders and participant's experiential narratives and the analysis of current processes and structures were carried out. The system requirements were specified for the proposed system. The proposed system application requirements were gathered through the interview method with the Human Resource (HR) officer to highlight the features and specifications of the desired system. Ten (10) users and stakeholders of the existing system from the government agency were used as respondents. Likewise, ten (10) staffs selected randomly from each department were also interviewed to know what their challenges and expectations are for such a system.

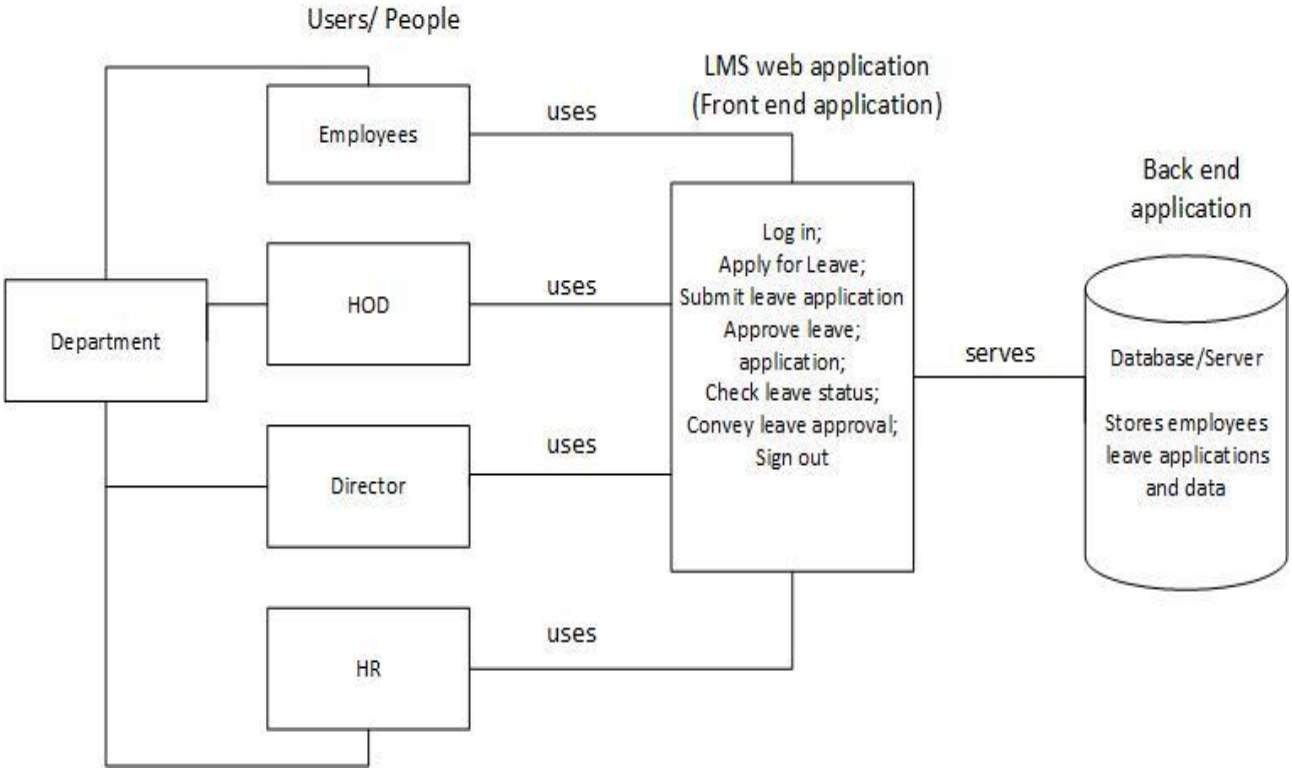

Figure 3. Proposed Design Framework

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1006

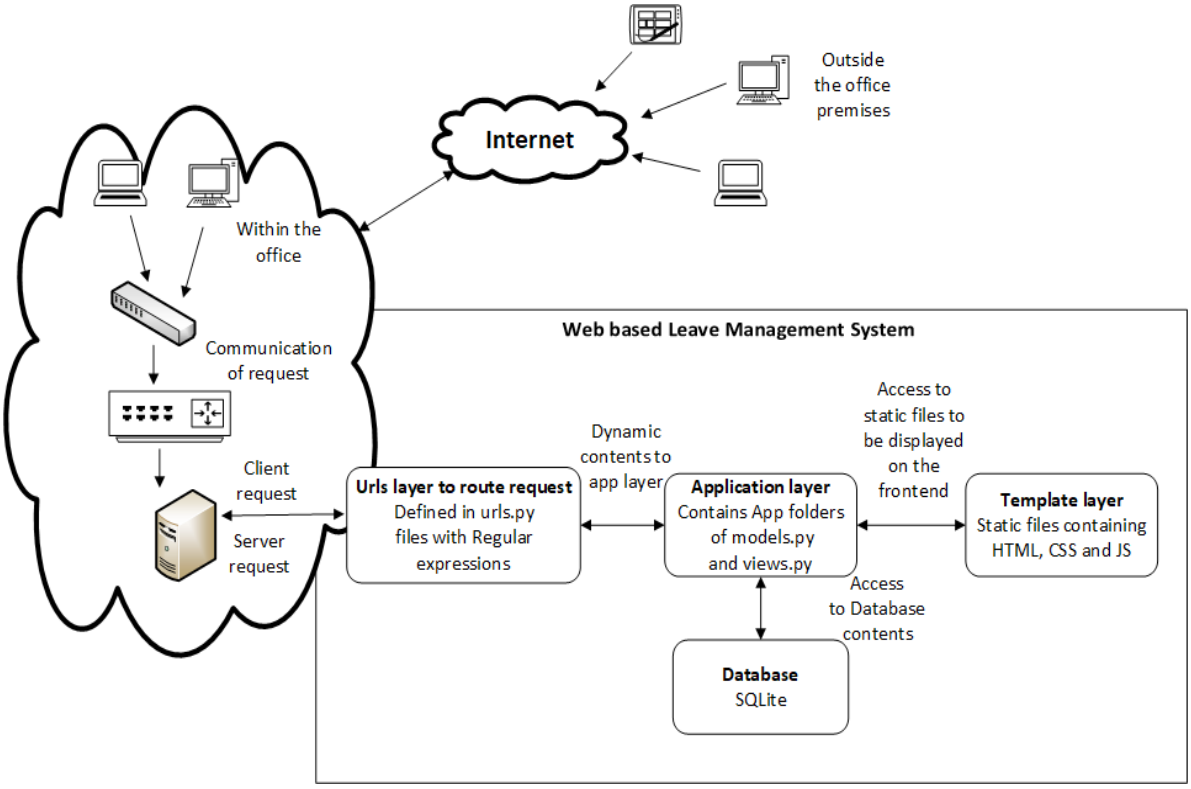

Figure 4: System Architecture for the Leave Management System

Table1: Sample Use Case Specification Table for the proposed Leave management System

S/N	Use Case name	Use Case Description	Participating Role
1	Log in.	The staff logs in to the system using a username and password to gain authorized access.	Employee, HOD, Director, HR Admin
2	Edit Profile.	The staff is allowed to update his/her profile e.g. home address, contact number, etc.	Employee, HOD
3	Request for Leave.	The staff selects a type of leave and submits his leave application for approval.	Employee, HOD
4	View Leave History.	The staff can view their previous leave applications that were approved or declined.	Employee, HOD

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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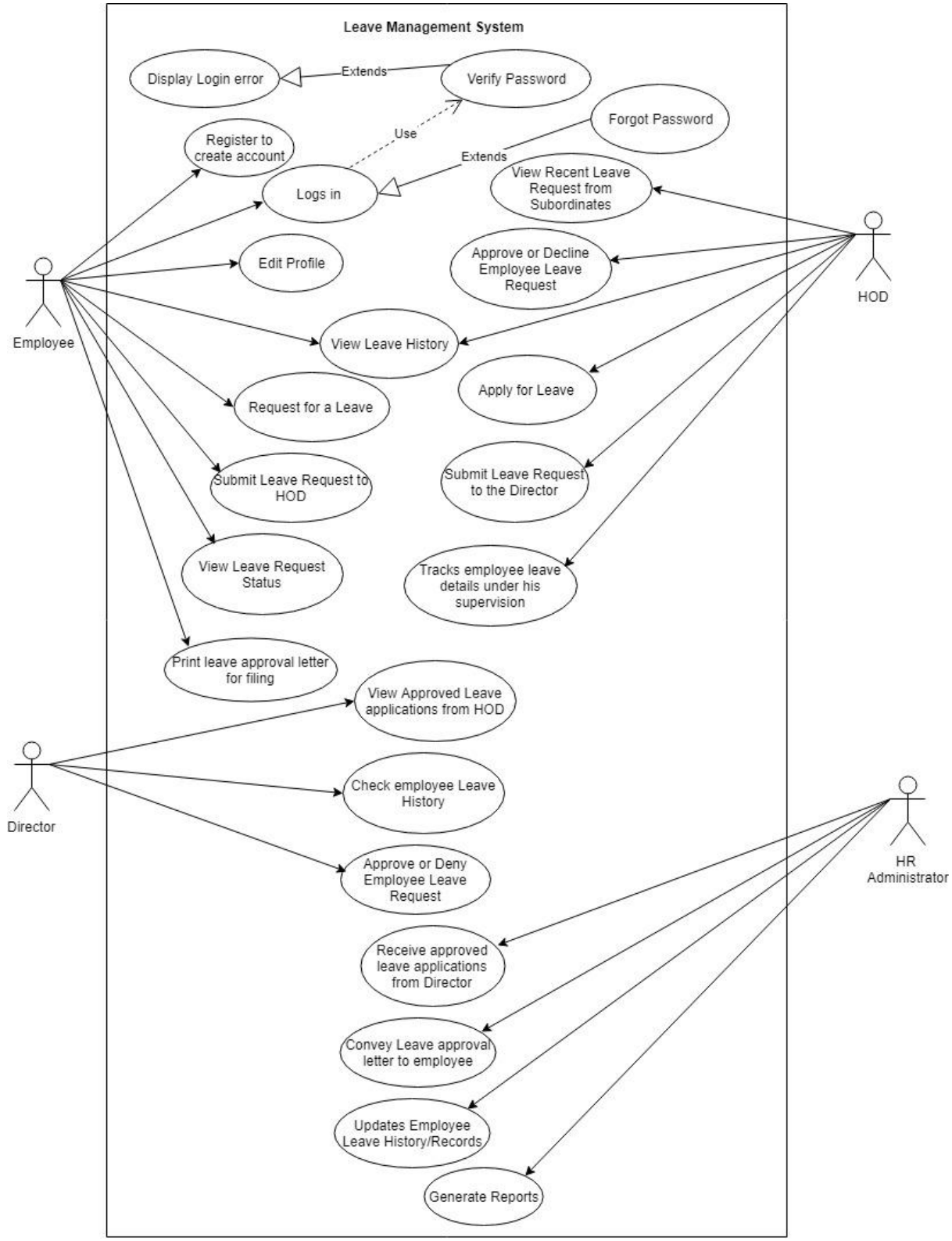

Figure 5: The Use Case Diagram of the Proposed Leave Management System

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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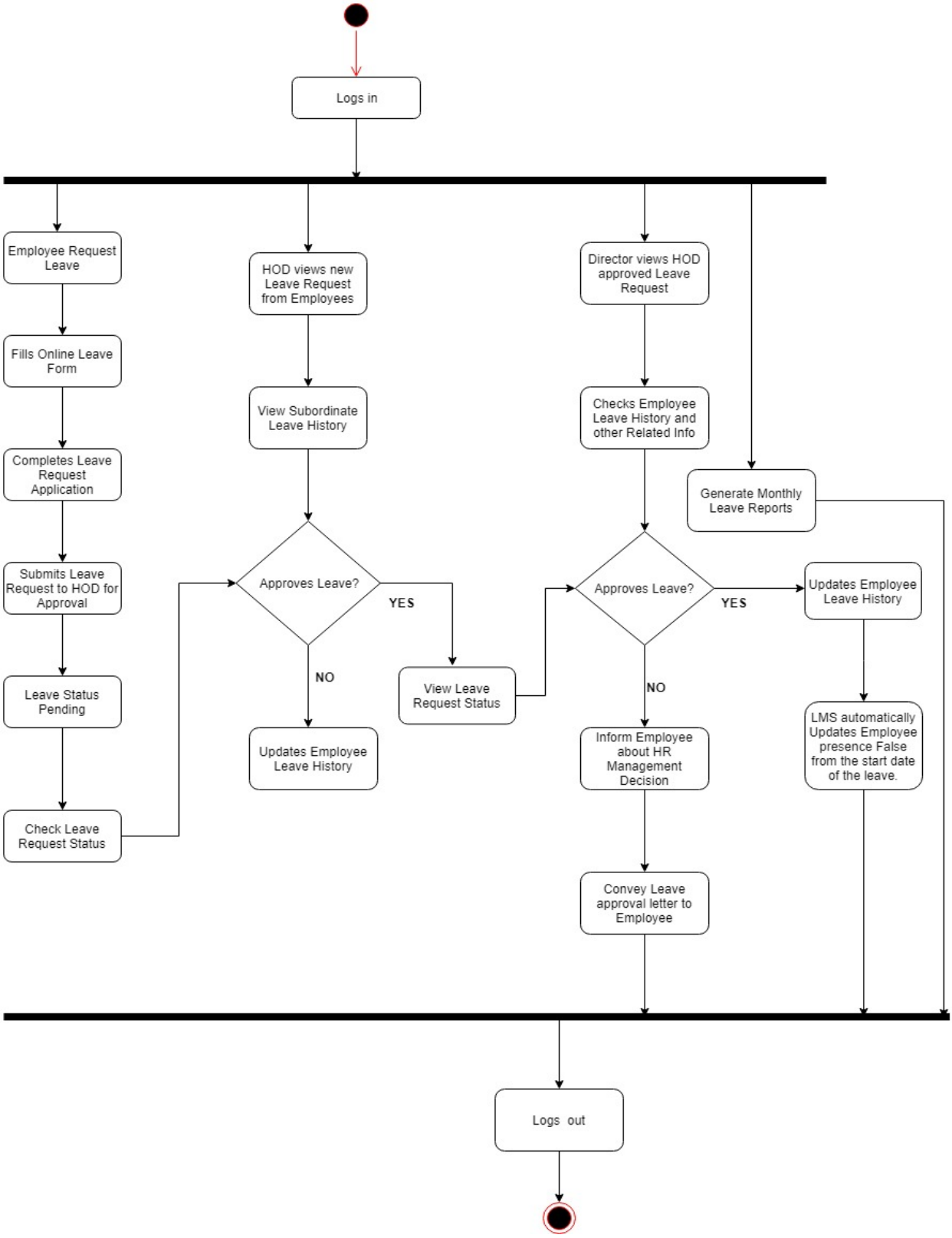

Figure 6. Activity diagram for the Leave Management System

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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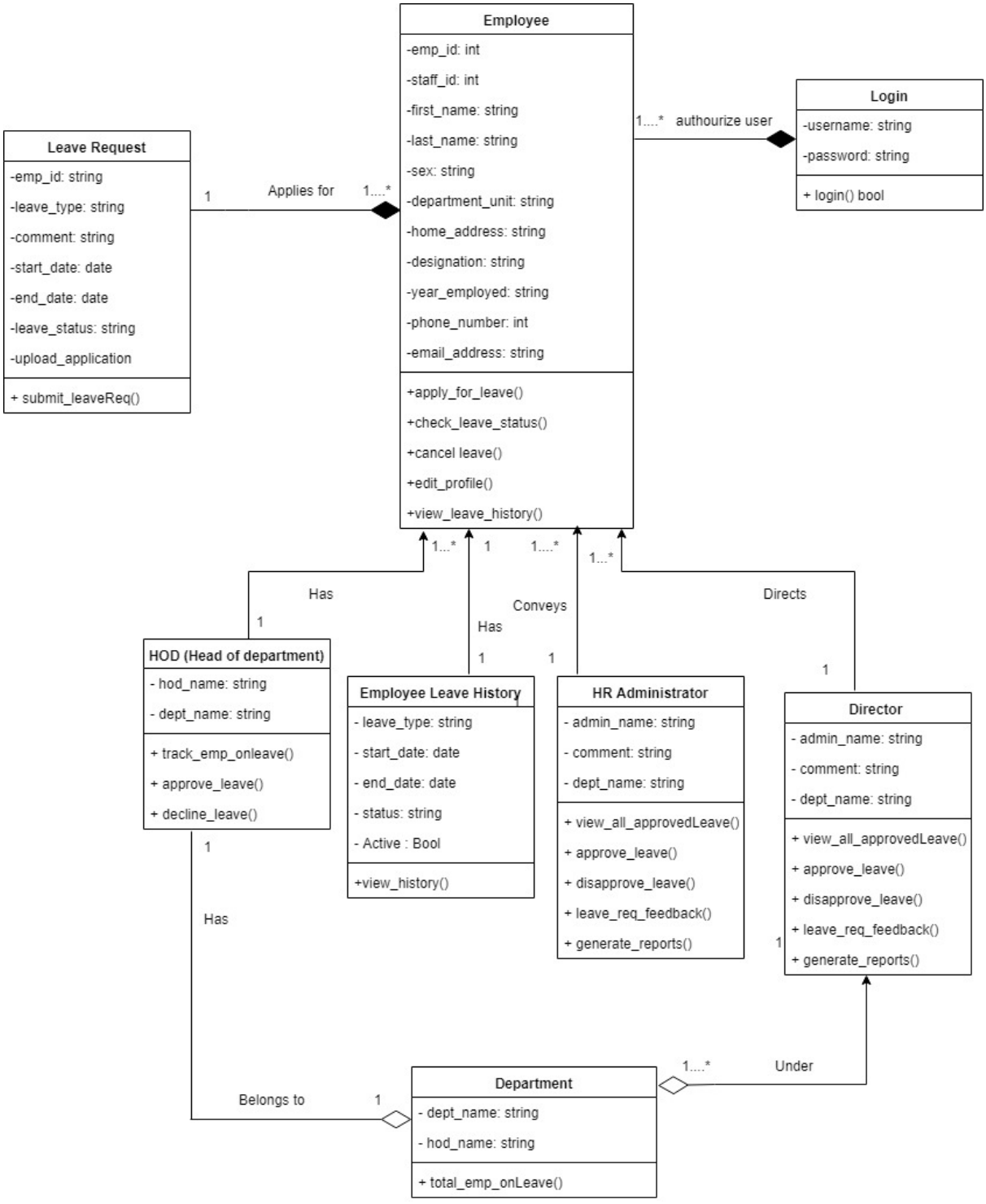

Figure 7. Class Diagram for the Leave Management System

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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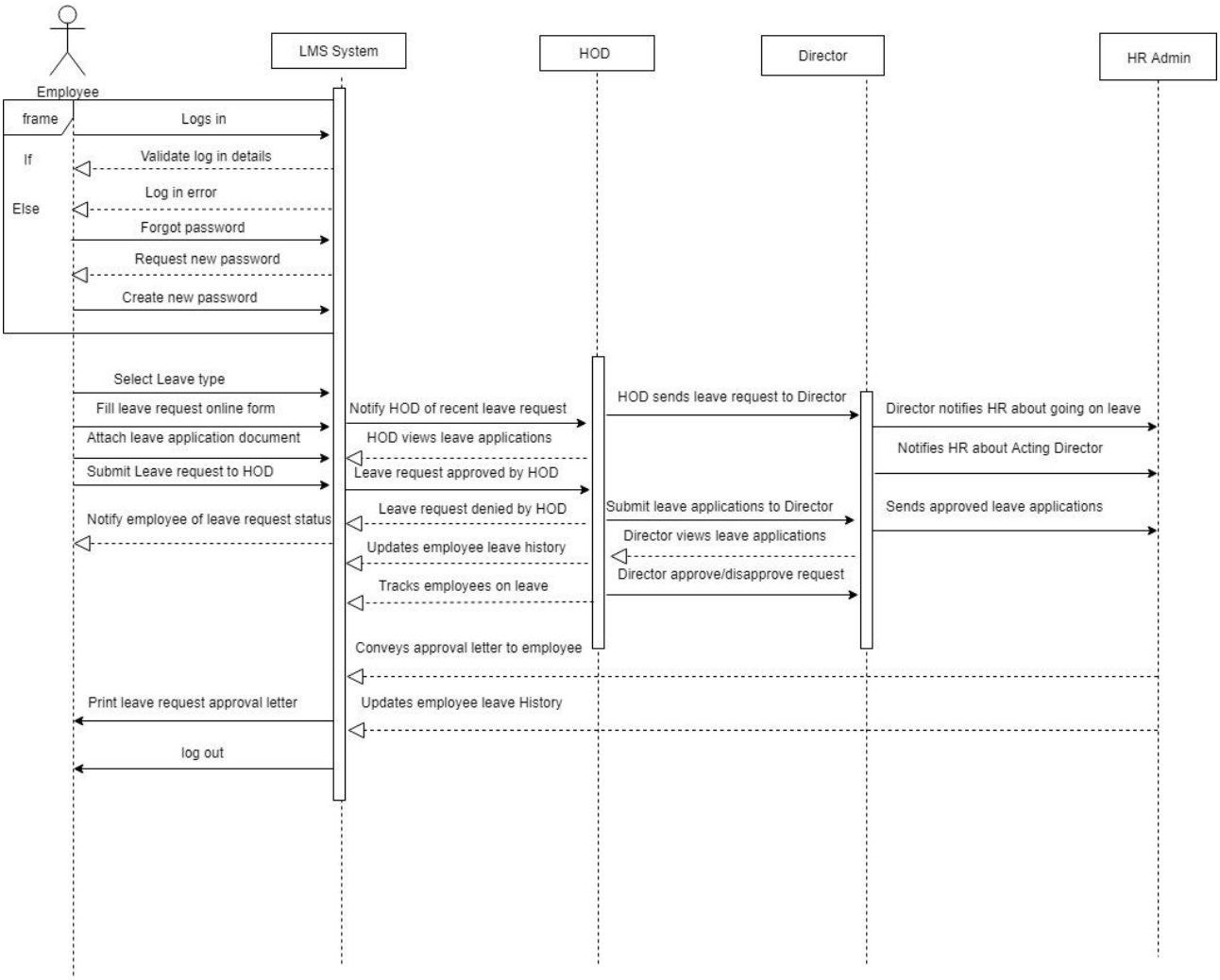

Figure 8. Sequence Diagram for the Leave Management System

Figure 9 shows the Entity Relationship Model diagram for the proposed LMS. The Entity Relationship Diagram (ERD) is a familiar diagram which presents the database structure of the proposed system in a Conceptualized form. Database design is built by the analysis of the problems then extract relational database schema. In addition, the ERD demonstrates that the real world is made up of a collection of entities, their relationships, and the attributes that define the entities. The entities represent the tables that will store posted data inputs from the users. The entities are:

i. Login table: To contain authenticated user information
ii. Employee table: This table contains the employee details
iii. General Employees table: This table contains all the employees leave details pertaining to a pending leave request.
iv. Employee Leave History table: This table contains previous employee leave applications submitted and other related information.
v. HOD table: The HOD table displays the Head of Department details in regards to leave applications and approvals.
vi. Super User table: The Super user table contains the HR administrator details. The HR administrator is responsible for granting employee leave approvals by management.
vii. Leave Request table: This table contains all the employee leave request applications submitted and pending for approval.
viii. Department table: This table contains all the names departments and their HODs that are within an organization.
ix. Approved table: This table contains employee leave applications listed for approvals by the HOD and the HR administrator.

The UML Component diagram illustrated in Figure 10 displays components provided and required interfaces, ports, and interactions between them in a UML Component design. It depicts a system's high-level design and gives a

physical representation of the system. The system component diagram depicts all software dependencies for the following components: Leave Request, Notification, Approve Leave, Track Leave, Leave History, and Report Generator. The diagram depicts the web-based Leave Management System's Service-Oriented Architecture (SOA).

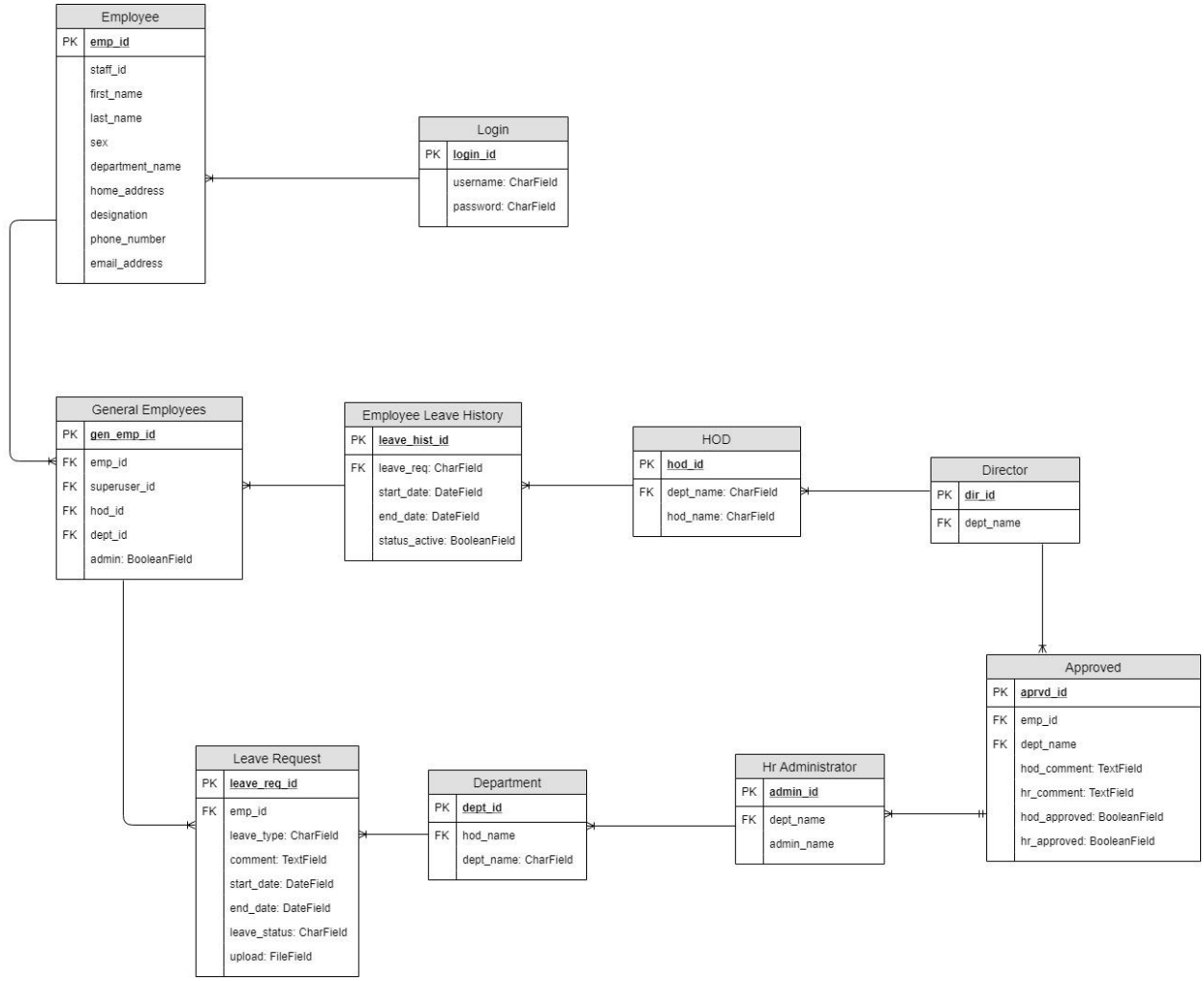

Figure 9. Entity Relationship Diagram for Leave management System.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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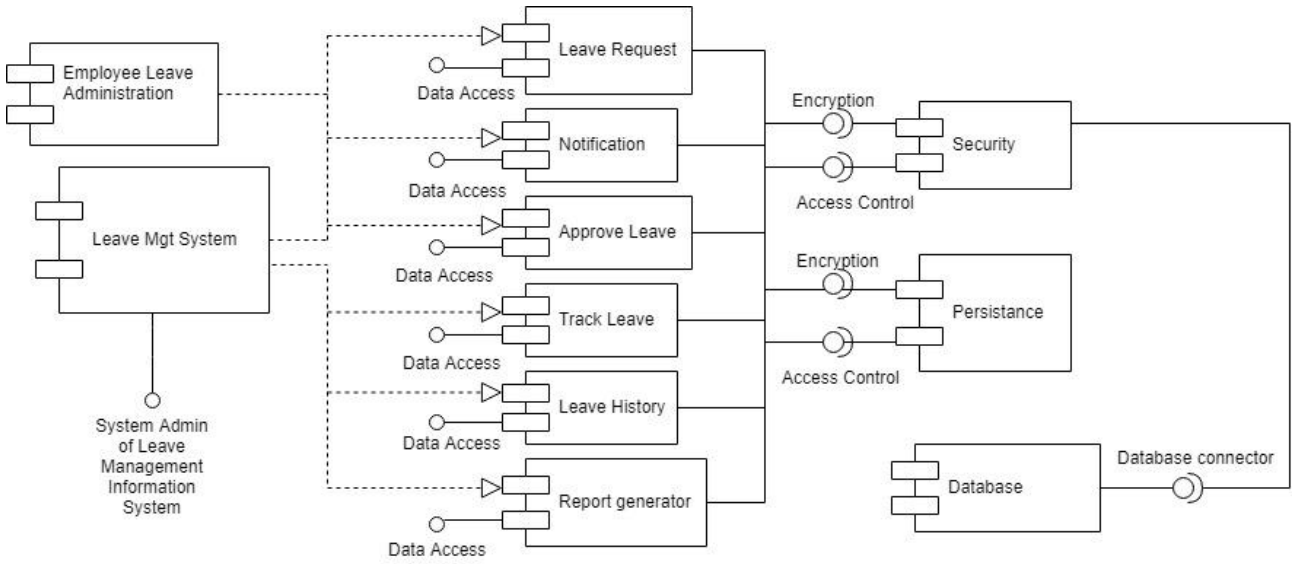

Figure 10. Screenshot of the Component diagram of the System

SQLite database management tool was used to design and implement the database aspect of the system. The use of the database tool was motivated by its availability, accessibility, simplicity and adaptive to the implementation language tool that was used in the development of the web-based system. Python programming language was used to implement the web-based automated leave management system application. The leave management system was implemented using web technologies, while McLean and Deleon information system (IS) theory was used to evaluate the developed system.

This was subsequently followed by a quantitative method using a statistical approach (descriptive approach) to provide both detail and generalized analysis, which serves as the basis for result presentation.

3.1 PROTOTYPE IMPLEMENTATION

The system design interface will be discussed here and results of the proposed system will be provided using sample data to test the system result output. This was designed to be captured and viewed by the different users. The system was designed to capture four different users Employee, HOD, Director and the HR Administrator. The implementation result is aimed at developing a prototype of the desired system specific for Public Parastatal Organizations. The following features define what the different interfaces delivers in line with the system requirements. The features of the web-based leave management system are;

3.1.1 The Home Page form

The Home Page form as depicted in figure 11 shows the landing page of the web application. The home page serves as the first contact page that all users will access to navigate and view other relevant features of the system. Every user visits the home page before logging into their personal leave account; while other features available on this interface is the login option and sign-up option. Figure 12 displays the Login page of the leave web application. The system will authenticate using the staff username and password before gaining authorized access to the his/her dashboard. Figure 13 shows the home page of the staff dashboard when he/she is logged in. On the dashboard, there are a number of functions that the staff can perform.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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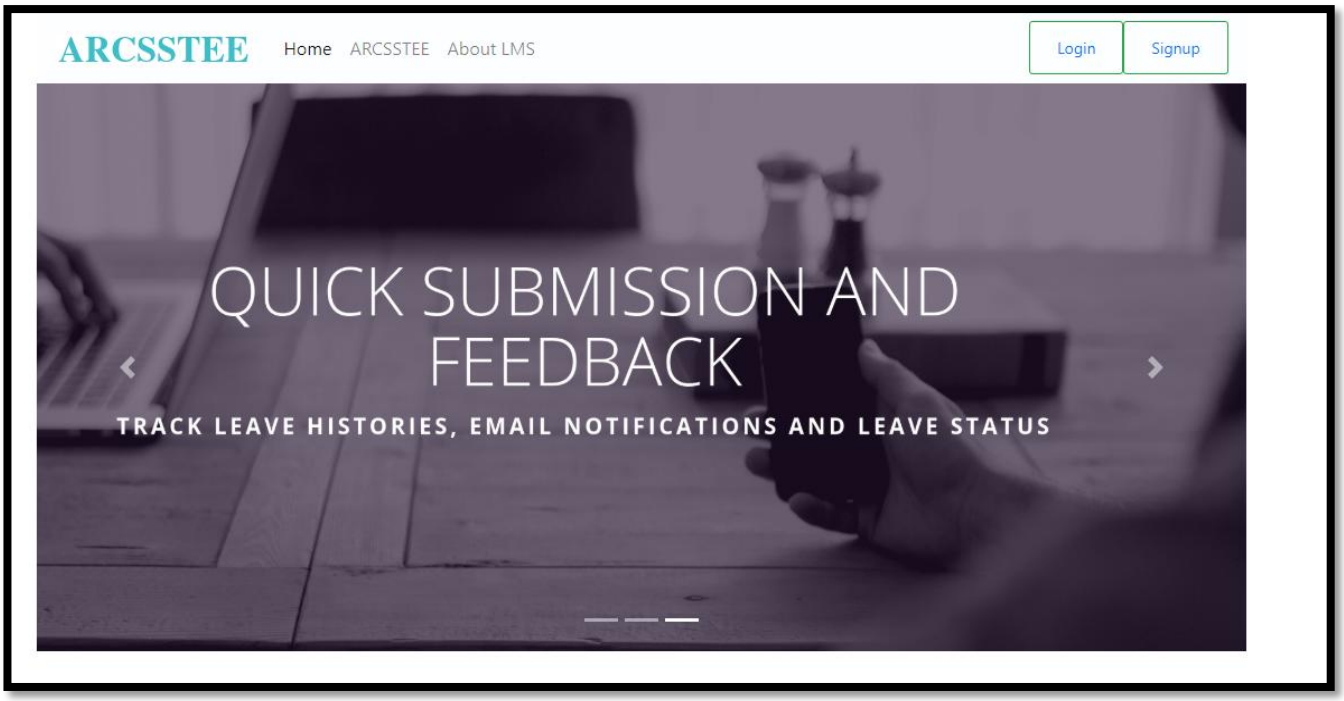

Figure 11. Web Based Leave Management System Home Page

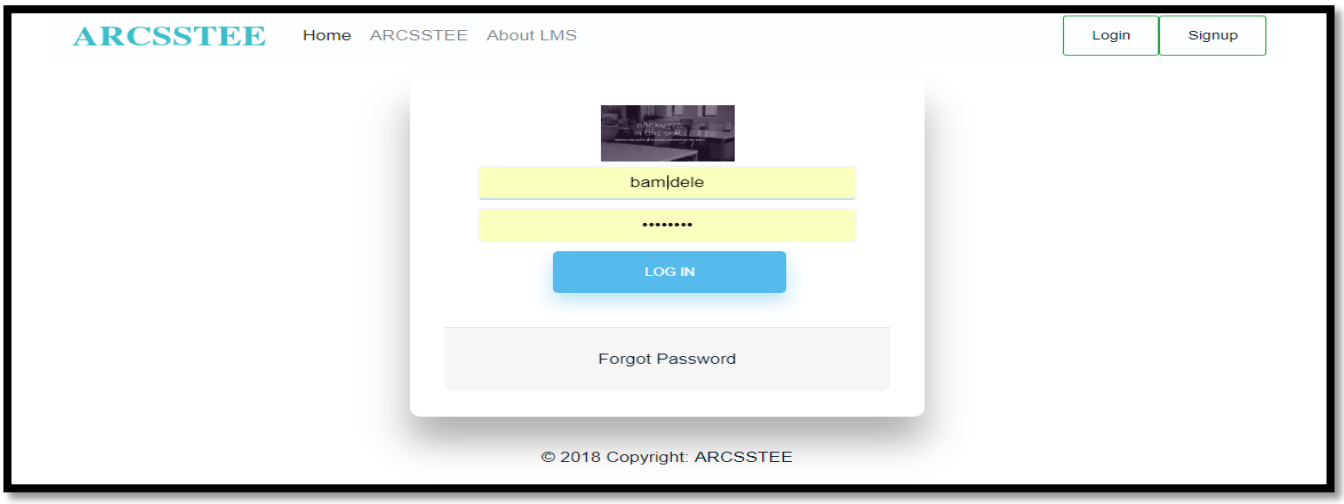

Figure 12. Web based Leave Management System Login Interface

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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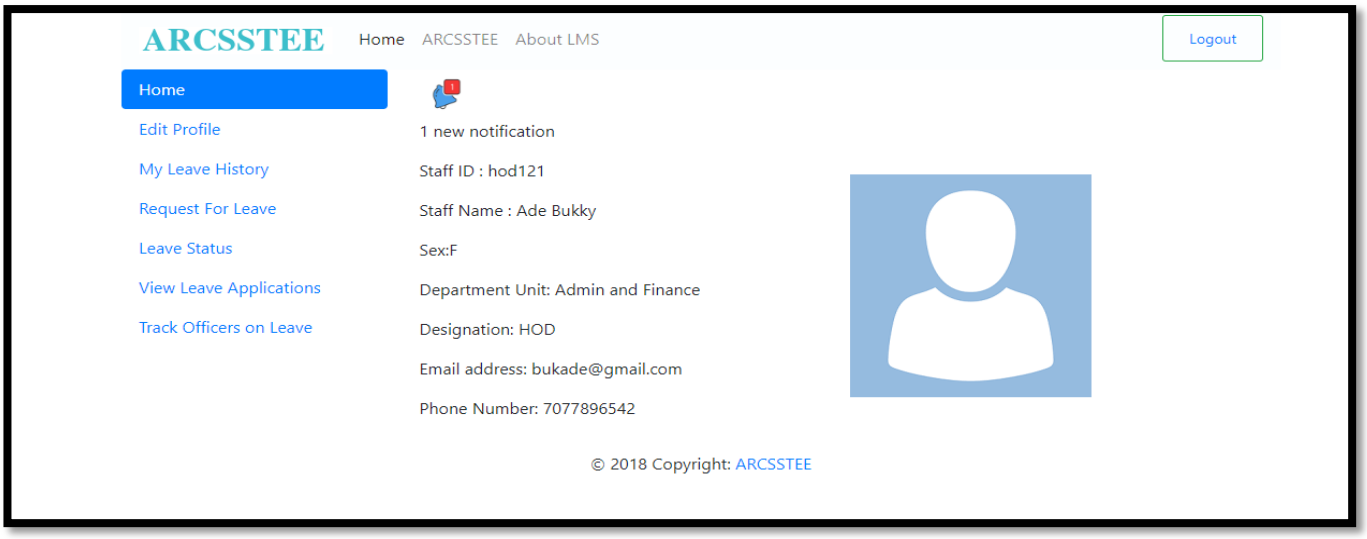

Figure 13. Screenshot of the Home Page of the Staff HOD

3.1.2 Staff Profile Form View

This is another feature of the new system. The form view is sectioned into 5 categories: edit profile page, my leave history, request for leave, leave status and leave application form. Figure 14 displays the edit profile page that permits staff to easily edit their previous information easily at the comfort of their workstations. Some of the features available for editing are their names, email address, home address, etc. In addition, My Leave History View as depicted in Figure 15 presents the leave history of all previous leave application approved or rejected via the Leave management system. It shows a table listing the leave type, application date, leave status, start date, end date and attached documents. Figure 16 displays the leave request application form where the staff will need to fill his leave intension before submitting it for the Director's approval. The staff is required to provide the leave type, start date, end date, and reason for leave request. While figures 17 and18 display the status of the staff leave application which will be initially pending. Here, the staff would subsequently check the submitted application is approved or rejected, displays a list of all staff leave applications submitted for the HOD's recommendation and assists the HOD to easily track employees currently on leave under his supervision easily. In the situation where the HOD needs to make a quick decision, he can easily track the leave information of his subordinates currently on leave

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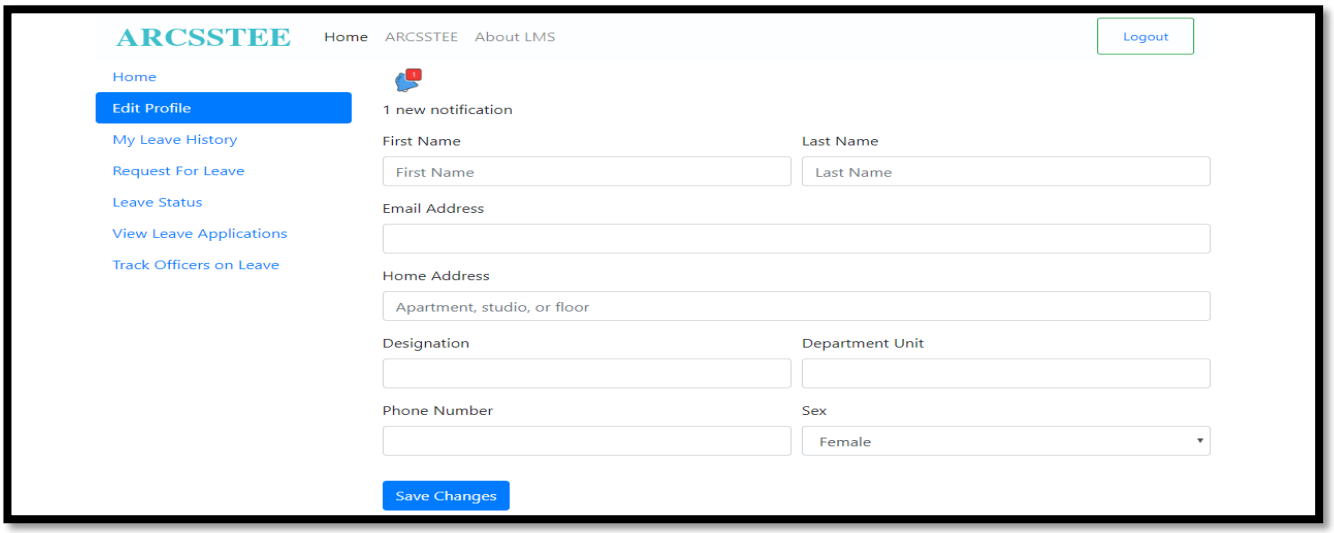

Figure 14. Screenshot of the Edit profile page for the staff HOD

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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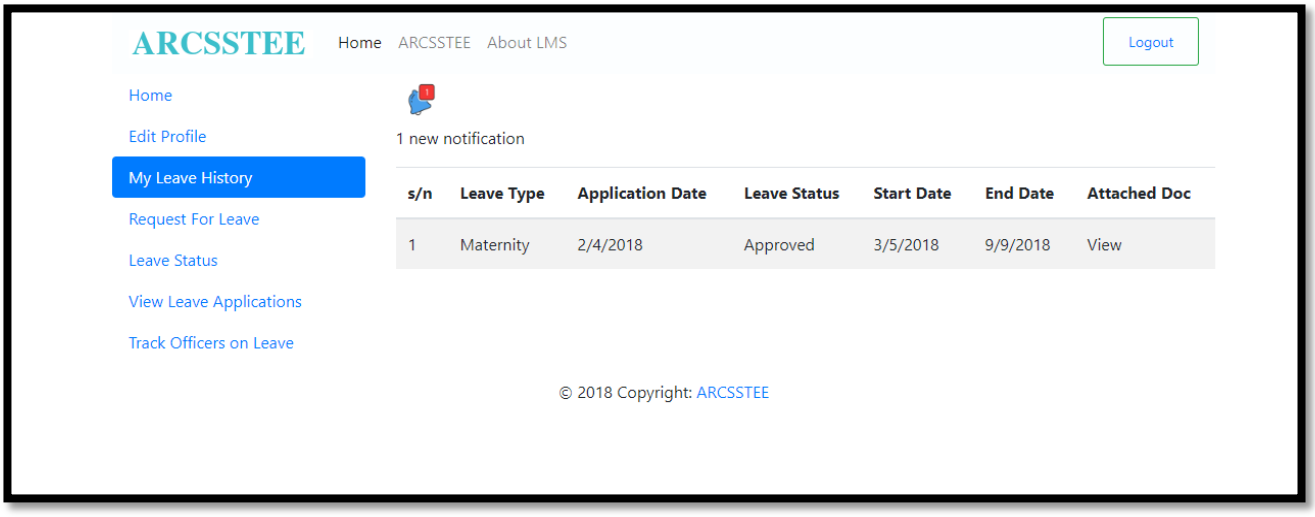

Figure 15. Screenshot of Leave History View

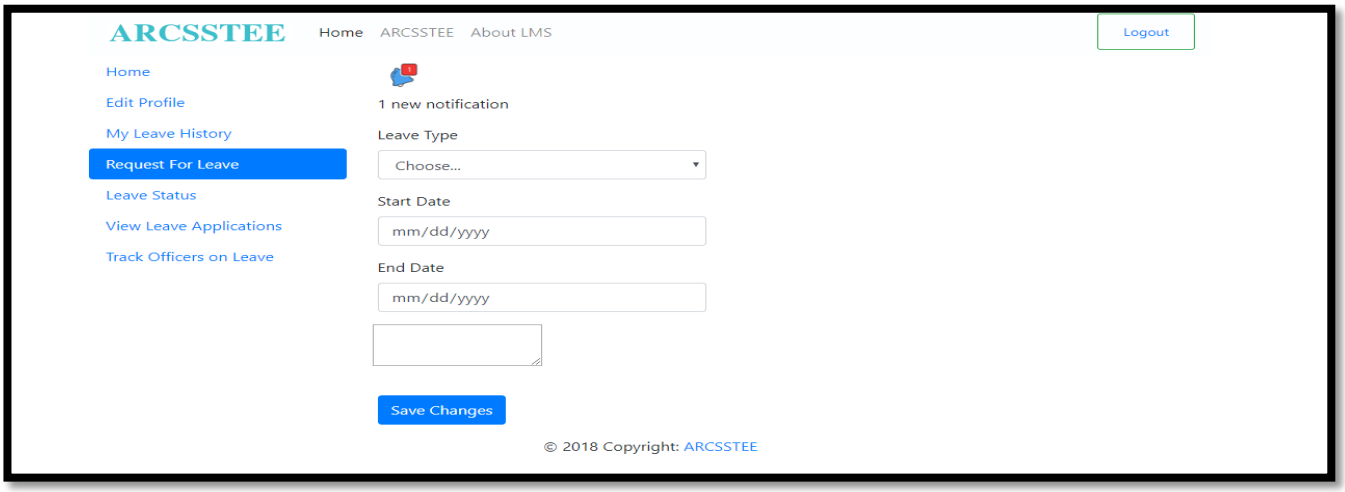

Figure 16. Screenshot showing Application Request.

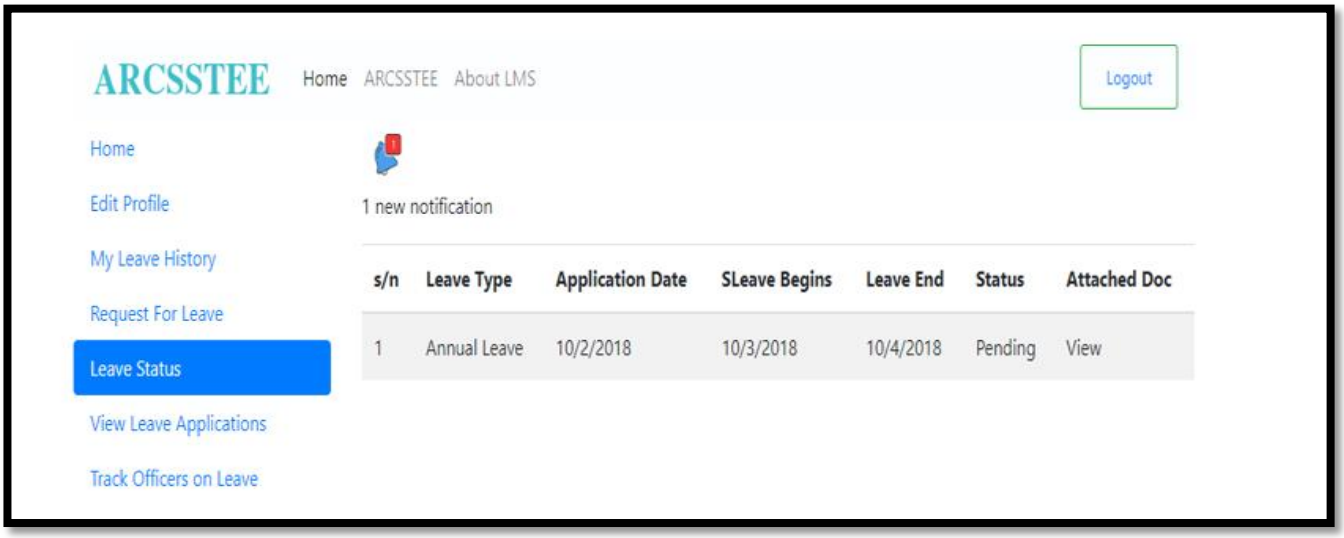

Figure 17. Screenshot Showing Leave Status for the staff HOD

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
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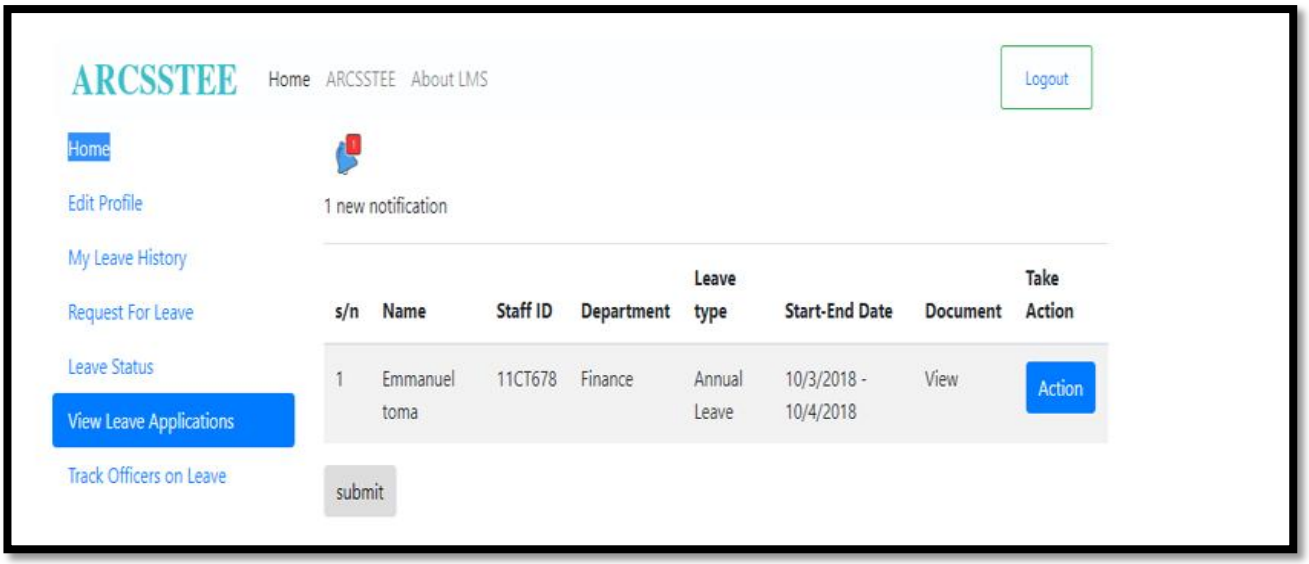

Figure 18. Screenshot Showing View Leave Applications

4. RESULT AND DISCUSSION

4.1 System Evaluation

The system was evaluated for performance based on DeLeon and McLean's information system theory. The system checks for performance accuracy and effectiveness using metrics such as information quality, service quality, user satisfaction, and net benefit through the use of the Decision Analysis Spreadsheet (DAS) tool. The DAS is a subjective evaluation analysis technique that measures the score or rate of the different categories of a parameter used in the assessment of the developed system. DAS is expressed as a single number in the range 1 to 5, where 1 refers to the lowest perceived quality and 5 is the highest perceived shown in Table 2. The responses received from respondents are presented in Table 3.

No.	Weight	Quality
1.	5	Excellent
2.	4	Good
3.	3	Poor
4.	2	Fair
5.	1	Bad

Table 2. Table showing the Rating Scheme

The parameters were rated by the respondents in the order of their score on the Nigeria computing system. As presented in Table 3, which is meant for substantiating each opinion and attitude of respondents relating to the quality of the developed system. The frequency of the parameters reveals the extent of the system quality as assessed by the respondents. Table 4 revealed that seven (7) respondents constituting about 70% have excellent usage with 30% of respondents have good use of the system. However, no respondent gave scores based on the other rating.

Nonetheless, 78.33% of the total respondent have good intention of use in terms of using the Leave Management system. 73.33% of the respondents accessed the system and gave the reliability score of the system, which produces consistent results time after time. The percentage availability of 83.33% obtained from the assessment shows that the system developed is available for use. Upon the use of the system developed, the response from respondents yielded 76.67%. This is indicative of the fact that when users (junior and senior staff) use the leave system, it was considered acceptable and good enough to achieve or meet the requirement specified.

Table 3. Table showing the System Evaluation Rating of the System Quality

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1006

Parameter	Excellent 5	Good 4	Fair 3	Poor 2	Bad 1	SoR	SoP	Avg	CWP
Usability	7	3	_	_	_	10	47	4.70	78.33%
Reliability	4	6	_	_	_	10	44	4.40	73.33%
Availability	10	_	_	_	_	10	50	5.00	83.33%
Response Time	8	1	_	_	_	10	47	4.70	78.33%
Adaptability	2	8	_	_	_	10	42	4.20	70.00%
Satisfaction	6	4	_	_	_	10	46	4.60	76.67%

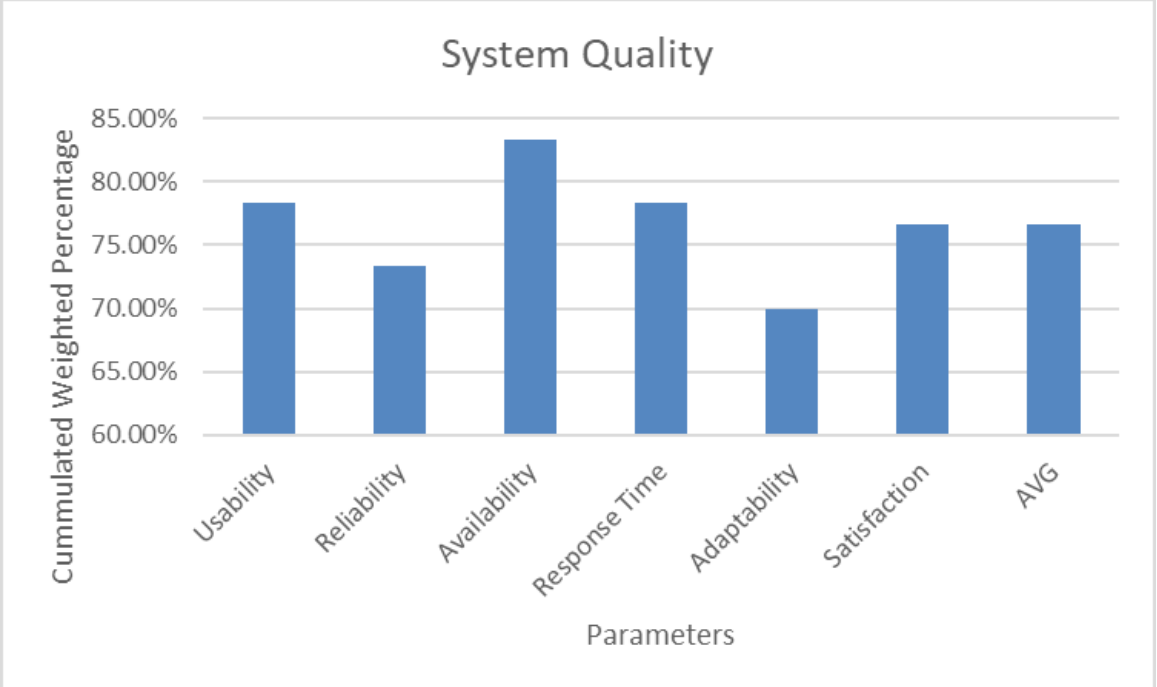

Figure 6: Graph showing the System Quality Rating

Similarly, 78.33% response rate obtained from the use of the system indicated that the leave request and approval is better compared to when manual or conventional method is applied. On the average, In conclusion, the average respondent rating on the quality of the LMS produced 76.67%. This shows that the system developed was able to meet standard conditions and requirements. In the same context, the graph of the Cumulative Weighted Percentage (CWP) against the rating parameters is shown in Figure 6. The frequency of the parameters reveals the extent of the system quality as assessed by the respondents.

Based on the evaluation model, the information quality measures the content issue such that the web-based application system developed be personalized, complete, relevant, easy to understand, accurate and secured. The result obtained from the evaluation of the developed system in terms of the quality of information is shown in Table 4. The table of score is illustrated for substantiating each individual opinion and attitude of respondents relating to the quality of information contained in the system developed. Based on the use of the developed system, the accuracy of the content (i.e., the ability to give precise outcome) gave 81.67% and having every necessary part of the requirement specified (completeness) produced 68.33% and 81.67% for ease of understanding the processes and procedures of use. Figure 7 depicts quality rating of the developed leave management system in a graphical form.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 123-144, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1006

Table 4: Table showing the System Evaluation Rating of the Information Quality

Parameter	Excellent 5	Good 4	Fair 3	Poor 2	Bad 1	SoR	SoP	Avg	CWP
Accuracy	7	2	1	_	_	10	49	4.9	81.67%
Timeliness	8	2	_	_	_	10	46	4.6	76.67%
Trustworthiness	8	2	_	_	_	10	48	4.8	80.00%
Completeness	1	9	_	_	_	10	41	4.1	68.38%
Easy to Understand	9	1	_	_	_	10	47	4.9	81.67%
Relevance	8	2	_	_	_	10	48	4.8	80.00%
Avg	5.67	2.83	0.17	_	_	10	46.83	4.68	78.05%

Figure 7: Graph showing the Information Quality Rating

Table 5: Table showing the System Evaluation Rating of the Usage

Parameter	Excellent 5	Good 4	Fair 3	Poor 2	Bad 1	SoR	SoP	Avg	CWP
Ease of Retrieval	8	1	1	_	_	10	47	4.70	94%
Ease of Navigate	9	1	_	_	_	10	49	4.90	98%
Nature of Use	7	3	_	_	_	10	47	4.70	94%
Number of Transaction	7	3	_	_	_	10	47	4.70	94%
Responsive	9	1	_	_	_	10	49	4.90	94%
Avg	7.80	1.80	0.20	_	_	10	47.40	4.74	94.8%

The System quality, Information quality singly or jointly affect the Usage and User Satisfaction of the system. The extent of use of the developed system gives 94.80% as shown in Table 5, which is a process that shows the

adaptation of the proposed LMS by the organization in need is excellent. However, the respondent's use of the system yields the system rating of 78.05% which is also significant. This is indicative of the fact that the system quality influences the usage. Consequently, the extent use of the LMS is closely related to user satisfaction as shown in Figure 6. In addition, the positive experience as shown from the result obtained using the system yielded 94.80%. The high evaluation rate leads to a significant user satisfaction rating thereby, showing that the user is good with the system functionalities and operations. Similarly, the use and user satisfaction influence the net benefit in such a way that it will reduces the time used in processing leave applications thus giving a cost-effective system when compared with paper-based leave filing system.

5. CONCLUSION

In this paper, web technologies have been used to develop a web-based leave management system for the public service organization. The application of information systems for leave management systems in human resource management provides a solution to the problem of data loss, delay and downtime which is inherent in the current leave management systems. As shown in the results, web or online approaches was used for resource management in organizations and agencies. This will produce a better approach towards the management of resource, processes, and requests in public service organizations. The use of the HRMIS in form of LMS will enhance employee productivity and management communication, help the management make better and well-informed managerial decisions thereby reducing the delay in leave approval, saves time and resolve most problems encountered during the use of existing systems. The use of mail notification will greatly improve the documentation, data management and quick approval of leave requests. When implemented, it affords the management to see the records of leaves approved for each employee or staff as well as check the leaves arrears through the Web application, removing time-consuming requests from the Human Resources Department using a regular Web browser, where Human Resource administrators can examine, update, and approve employee time and leave from any location. The aspect of leave application management is a fundamental aspect of human resources and therefore, essential that delays are reduced when processing a leave application. Leave matters however can be handled more effectively if public organizations begin to appreciate the solutions that Information Technology offers as an effective supporting tool.

6. ACKNOWLEDGMENTS

Our thanks to the researchers who have contributed towards development of the system.

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International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 145-154, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1007

Minimizing Routing Overheads in Zone Routing Protocol (ZRP); Replacing Zone Radius with Node Location Information

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Abstract: There are many routing protocols suggested for use in Mobile Ad Hoc Networks (MANETs). Among them (the routing protocols) is the Zone Routing Protocol (ZRP). ZRP uses the concept of zones to ensure that proactive activities are limited to a defined area around a node. The zone is determined by the radius (hops). By limiting a proactive zone on the radius, the transmission of data packets is made effective. However, any node that resides beyond the zone, is reachable reactively. The literature review indicates that one of the shortcomings in ZRP is the overlapping of zones. Furthermore, the exercise of determining zone radius is complicated. The overlapping of zones occurs because individual nodes and their zones are determined by a hop-count radius. Consequently, this overlapping of zones leads to increased routing overhead in ZRP. In an effort to resolve zone overlapping and thus reduce routing overheads, this study suggests the application of the Location-Aided Routing (LAR) Scheme I in the Interzone Routing Protocol (IARP) scheme of ZRP. By applying LAR Scheme 1 algorithm, the need for a hop-count-based radius is eliminated. Location information of nodes in IARP ensures that zones do not overlap, resulting in reduced routing overheads. This study simulates elementary parameters of delay, drop rates, deliver ratio, and the general throughput of ZRP based on the number of nodes, the area, and the size of the data packets. The conventional algorithm of ZRP was rendered on NS-2 and while the nodal-location enhanced ZRP algorithm on OMNET++. Simulation results suggest that the positionally enhanced ZRP algorithm minimizes zonal overlapping hence better data packets throughput, minimized delay and drop rates, and augmented data packets delivery ratio.

Keywords: Zone Routing Protocol (ZRP), Zonal Overlapping, Routing Overheads, Data Packets Throughput, Mobile Ad Hoc Networks (MANETs)

1. INTRODUCTION

Mobile ad hoc networks (MANETs) are the mobile networks created "for the purpose of" responding to a particular situation [1, p.2]. They are made up of mobile devices(nodes) that connect to form autonomous networks independent of infrastructure [1]. Due to this autonomy—nodes can leave and join the network willingly, MANETs are very dynamic. Mostly, MANETs are temporary because they are established in emergency situations such as rescue operations. Another application of MANETs is the formation of military communication networks in war zones. More recently, however, MANETs' applications have extended to education in the form of mobile learning (m-Learning) and e-Learning [2],[4]. Due to their extemporaneity, MANETs do not need pre-existing infrastructure.

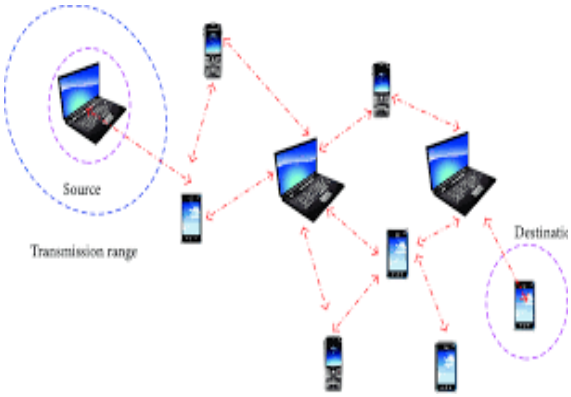

Figure 1: An example of a Mobile Ad Hoc Networks (MANETs) [2]

Routing protocols are used in data packets or signal propagation among nodes—from the host to the receiver. However, since MANETs adjust their topological structure continuously, its routing protocols must be robust enough to accommodate these updates. For instance, as nodes

autonomously leave and join the network, previously-stored topological information must change. In the process, routing tables are updated according to these changes. Due to this dynamism, MANETs routing protocols should be vigorous enough to support signal and data transmission. Critically, selected routing protocols must select the most proficient route from the host node to the destination node.

Categorization of routing protocols can be accomplished through consideration of the topology of the network. By using this criterion, routing protocols can be categorized as either proactive or reactive. Moreover, routing protocols can be classified based on the style deployed for communication. This method of classification yields a unicast, broadcast, and multicast routing [20]. Regardless of the routing group, however, all routing protocols should be able to efficiently support data packet propagation from one node to another.

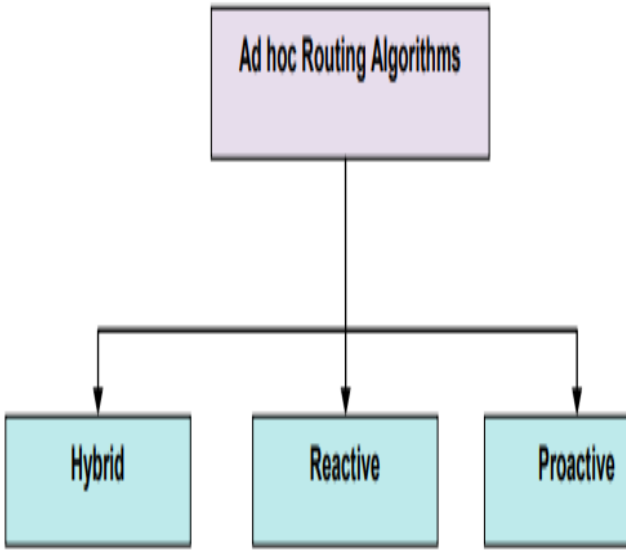

Figure 3: Generalized MANETs Routing Protocols Classification [17]

Proactive routing protocols maintain routing information during network operation. This happens regardless of the need for information by the network nodes. Without reception of a trigger route discovery request, proactive routing continuously updates routing tables as nodes join or leave a network. Routing tables maintain the topological information of every node within a network. Routing tables necessitate sporadic updating as autonomous nodes either connect or disconnect from a network.

Because proactive routing protocols preserve and maintain the topological routing data of the entire network nodes, they are wasteful and unfitting for use in highly interconnected networks. Constant updates produce increased overhead such as bandwidth, thus making proactive routing protocols wasteful—they may need more power to operate. Oppositely, routing table-dependent— reactive protocols, avoid continuous updates of their routing tables with nodal topological information. Routing tables updates occur only on-demand basis. That is, upon route discovery request by the neighboring nodes. The absence of continuous updates of routing tables yields lower overhead such power, hence making reactive routing protocols viable for large networks. However, a lack of constant updates of routing tables may result in an amplified latency [34].

When the strengths of individual proactive and reactive protocols are combined, hybrid routing is created. The concept of hybrid routing protocols is intended to moderate the overhead shortcoming of proactive routing and reduce data packet latency. Route discovery service and process in reactive protocols create latency inside an ad hoc network. Primarily, Hierarchical routing is installed in highly interconnected networks.

The core objective of this study was to use simulation and scenario illustration to determine a suitable algorithm to reduce overhead and increase transmission capacity by ZRP as a result of minimizing routing zones overlaps. The explicit aims of this study comprised the following goals:

1. To create an appropriate algorithm to reduce routing zones overlap and consequently minimize overhead in ZRP and increase the transmission capacity of selected scalar parameters.

2. To empirically (through simulation) demonstrate the viability of the created algorithm.

2. ZONE ROUTING PROTOCOL

Several studies indicate that proactive routing creates a lot of overheads as a result of utilizing excess power to maintain routing information [35]. Moreover, reactive routing protocols experience long delays in the route request. Another shortcoming of the reactive routing protocols is their tendency to flood all the nodes with route request information. The flooding technique is inefficient because it can lead to added routing overheads [35].

The Zone Routing Protocol (ZRP) is proposed in [6], [7], [8], and [13] with an intention to address the shortcomings of both pure reactive and proactive routing protocols. According to [14], this is only achievable by merging the strengths of both reactive and proactive routing protocols. ZRP is regarded as a hybrid routing protocol because it combines the advantages of reactive and proactive routing protocols. In an ad-hoc network, route request is based on neighbor discovery service [6], [32]. Consequently, ZRP decreases the proactive coverage to a zone centered around every node. According to [20], a reduced zone helps in increasing the effectiveness of data packets transmission. In addition, a limited zone is critical in ensuring reduced data packets loss and wastage of the power. As a result, the proactive overhead goes down.

However, the nodes outside individual zones are reachable reactively—the reactive routing is called to action. Because

nodes in specific zones keep up-to-date local routing information, route requests are better conducted proactively by avoiding the flooding of all nodes with request messages. According to [40], regardless of the use of zones in ZRP, the organizational overhead is avoided because of its flat view nature. Unlike the hierarchical routing protocols, ZRP views the network flatly thus avoiding the overheads that accompany network levels. ZRP does not need to strategically assign gateways or landmarks to nodes for access to the entire network. In ZRP a node can reach the rest of the network nodes because there is no hierarchy. Congestion in ZRP is avoided because there are no subnets [33]. The overlapping property of network zones in ZRP makes it a flat protocol. Therefore, it is possible to determine optimal routes and reduce congestion [6]. Notably, ZRP is an adaptive routing protocol whose use is highly dependent on the existing configuration of the network.

Suggested by Haas and Pearlman in 1997[7], ZRP has been lauded for its robustness, particularly in large network implementation. However, a key shorting is the overlapping of it routing zones thus augmenting overheads—such as power consumption. Every node in ZRP belongs to a zone within a MANET. The size (radius) of routing zones in ZRP is determined by the number of hops from the transmitting node to the receiver node. Because ZRP is a hybrid routing protocol, it combines favorable features from proactive and reactive routing protocols [22]. A single local zone uses proactive routing while the inter-zonal transmission is realized through reactive routing. Although proactive routing risks an increased routing overhead, this shortcoming is compensated through reactive routing in interzonal communication [7].

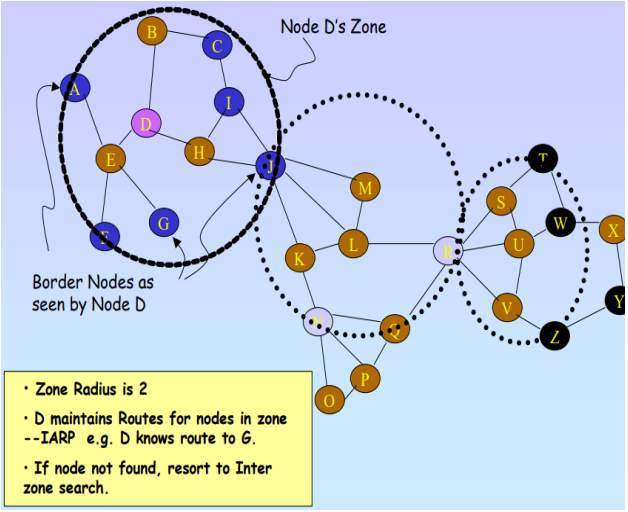

Figure 5: A 2 hops radius routing zone [38]

Figure 5 demonstrates the idea of a 2 hops radius routing zone. For demonstration purposes, most illustrations in research papers use radius of 2. All nodes within this routing zone lie within the radius of D, measured in 2 hops. Node D is the central node from which the location of every node within or without the radius is referenced. For example, if a node is within the radius of 2 hops of central node D, it is considered to lie within the routing zone. However, if a node lies beyond 2 hops from the central node D, it is considered to be outside the routing zone. For communication to be established, the nodes within the routing zone centered at D must use a border casting service.

Referring to figure 4, nodes that belong to the routing zone centered at D, are A through J. However, node L is not within the routing zone because it is beyond the radius of 2 hops. That is, in reference to node S, node L is 3 hops—exceeding the 2 hops radius. Peripheral nodes are composed of nodes whose radius is exactly the number of hops used to define a routing zone. In figure 4, nodes A, F, and J are peripheral nodes in reference to central node S. Characteristically, ZRP routing zones are illustrated as a circle containing a central node—such as node D in figure 4. It is critical, nonetheless, to note that a routing zone does not correspond to an actual representation of the physical distance of mobile devices. The circular representation of routing zones in ZRP characterizes connectivity in form of hops radius. Illustration of ZRP routing zones demands neighbors discovery. Neighboring nodes are the node that communicates directly because they have a single hop between them.

Neighboring nodes in a ZRP routing zone can recognize each other through media access control (MAC) addresses. However, the neighbor discovery process can be achieved Neighbor Discovery Protocol (NDP) service. In NDP, beacons are utilized in broadcasting frequent "hello" messages to identify neighboring nodes. Upon reception of the beacon messages ("hellos"), a node assesses its quality to gauge the status of connectivity.

Connectivity status information generated by the neighbor discovery protocol is applied in the proactive routing in the Interzone Routing Protocol (IARP). Because IARP is proactive in its routing, its functionality can be generated from pre-existing and well-known proactive routing protocols such as Open Shortest Path First (OSPF). Proactive link-state routing protocols offer a comprehensive representation of network connectivity. However, the substitute proactive link-state routing protocol should be altered to restrict its operations within the defined radius of the routing zone.

There are two routing concepts used in ZRP. The Intrazonal Routing Protocol (IARP) is used for routing among the nodes in a single zone. Nodal communication beyond the IARP is executed by the Interzone Routing Protocol (IERP). Peripheral nodes in a zone ensure communication between the IARP and the IERP. Peripheral nodes achieve this feat through border casting service called Neighbor Discovery Protocol (NDP).

By using the route information as generated on IARP, the reference source node establishes the location of the destination node. That is, whether a node is within or without

the local routing zone. If the node is found within the local zone, routing is conducted proactively. Reactive routing is used if the destination node lies beyond the local zone [9]. During the reactive route discovery procedure, two stages are involved. That is the route request phase and the route reply phase. During the route request phase, the source node transmits a route request data packet to the peripheral nodes by deploying BRP. When the request message arrives at a receiver node that knows the destination node, a message is sent to the source node. Else, the process of border casting the data packet continues. This continuous propagation of data packets ensures that every node in a network is contacted. According to [10] and [11], if a copy of a request data packet is sent to several nodes, they are labeled redundant and consequently discarded.

For a node to reply to the source node, it is necessary to accumulate routing information along the way—as the packet is transmitted from one node to another. Such network routing topological information is recorded in either the route request packet or as next-hop addresses in the nodes together with the transmission route. On the route request packet, the route discovery request node attaches its address and the pertinent node/link metrics to the data packet.

Upon the packet arriving at the destination node, the sequence of addresses is reversed and copied to the route reply packet. Afterward, the sequence is used in forwarding the reply message back to the source node. Alternatively, the forwarding nodes may record "routing information as next-hop addresses, which are used when the reply is sent to the source" [8]. In the second case, it is particularly advantageous because it can lead to the reduction of transmission overheads because the request and reply packets are comparatively reduced. Furthermore, the source node can receive the entire source route to the destination. Otherwise, the nodes situated along the route to the destination node record the next-hop address in their routing table.

During the border casting exercise, a source node transmits a route request packet to each of its peripheral nodes. Because border casting occurs in one-to-many transmission, it deploys multicasting hence lowering the route discovery overheads. Allowing the source node to compute the multicast tree and append the route discovery information to a packet is one of the approaches used in ensuring that route overheads are lowered. Resultantly, this approach is called Root-Directed Bordercasting (RDB). Alternatively, it is possible to recreate the tree at each node, while omitting the routing instructions. However, such a procedure necessitates that every internal node knows the topology seen by the border casting node. Accordingly, it is essential that the nodes preserve and sustain a protracted routing zone with radius 2ρ-1 hops. Markedly, the distance of the peripheral nodes to which the request is transmitted is *p*. As a result, this method is known as Distributed Bordercasting (DB) [6].

According to [3], zone radius is a critical feature in the performance of ZRP. A zone radius of one hop leads to the use of pure proactive routing resulting into bordercasting that is dependent on flooding route requests throughout the network. Oppositely, an infinite radius size leads to reactive routing. Subsequently, the selection of radius is a compromise among the routing effectiveness of proactive routing and augmenting traffic in a network.

3. THE PROPOSED LAR-ZRP ENHANCED ROUTING PROTOCOL

Since in ZRP, proactive routing zones severely overlap, query control traffic may increase [15]. Besides, "since the actual implementation of IARP and IERP is not defined, the performance can be further improved by adapting other routing protocols as ZRP components" [15]. Furthermore [16] notes that one of the shortcomings of ZRP is the lack of use of location information in route discovery query. Location-aware routing helps in reducing some of these shortcomings to some degree [9]. Through the use of a Global Positioning System (GPS), it is possible to minimize the query traffic [16].

In this study, a position algorithm that replaces the hop-count-based radius is proposed—figure 12. Because the implementation of IARP is not defined—it is open to be modified based on scenario needs, we propose that instead of defining zone radius with the hops counts to the peripheral nodes, an expected zone and a request zone is determined based on the transmission range of a node.

While the IARP can be implemented through various proactive protocols, this study considers the algorithm of the Distance Vector as presented in [7] and [9]. The algorithm is modified to fit the location information of a node, thus eliminating the need for a zone radius.

The modified algorithm allows the reception of new route information by a source node as transmitted within the request zone. In case a node is not found within the request zone, the invocation of Neighbor Discovery/Maintenance occurs. Communications between the source node and the destination node takes place if the two nodes are within the request zone; with radius r as indicated in figure 12. The location information exchanged include the distance between the nodes and the Angle of Arrival (AoA). The received new location information can then be stored by the source node in its Intrazone Routing Table. Updating of location information is carried out in the IARP through the Neighbor Discovery/Maintenance Protocol. The following pseudo code explains the role of introducing the LAR scheme 1 into the IARP of ZRP.

Because the hypothetical nodes serve both as receiver and transmitter, they are technically hosting. Therefore, the 100 in a characterized scenario are the hosts.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 145-154, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1007

4. RESEARCH METHODOLOGY

Comparative literature process as outlined in [36] was used in identification of the routing protocols for study and simulation. As part of this study, documentation of possible complementary behavior of MANETs routing protocols was conducted. Consequently, selection of the routing protocols carried out on [12], [37], [38] and [39] categories. Two routing protocols are selected arbitrarily from each of the categorizations, with DSR and AODV representing the flat-proactive grouping. In the flat-reactive category, DSR and AODV are selected. However, automatic selection of a routing protocol was done if a routing protocol appeared more than once in categories [24], [25], [26], [27 and [28].

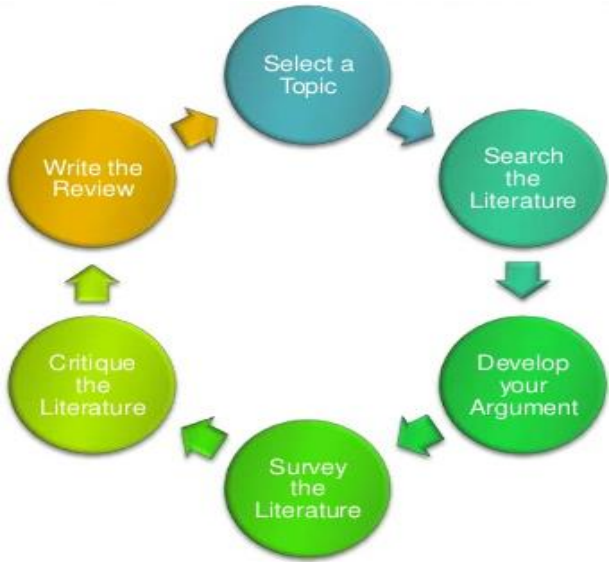

Figure 13: Literature Review Process. Adopted from [31]

Purposive sampling was applied in the identification of ZRP as the routing protocol for simulation. Because purposive sampling relies on the experience and intentions of the researchers based on the subject under investigation, it was decided that ZRP is robust for a highly interconnected MANET network [43]. Since ZRP combines reactive and proactive properties in its routing, its operational performance is a reasonable representation of the cumulative benefits from both categories. Through experience as network engineers and administrators, ZRP is a robust and dynamic routing concept applicable in vastly interconnected MANETs networks. Additionally, literature review identifies ZRP as a viable MANET routing protocol because it combines both reactive and proactive routing properties.

To ensure some level of consistency, reliability and validity of results, this study used two simulators. First, the conventional ZRP was simulated on NS2—which works best with linux systems. The proposed position-location boosted ZRP algorithm was simulated on OMNET++ [42]. Metrics collected and analyzed on data packet size, number of nodes and the characterized area. On network simulator NS2, this study used the simulation trace file which is formed during simulation. Later the metrics from the simulated parameters were rendered into plotting graphs and the available animation properties. Simulation platform on NS2 are built on C++ and Object-oriented Tool Command Language (OTcl).

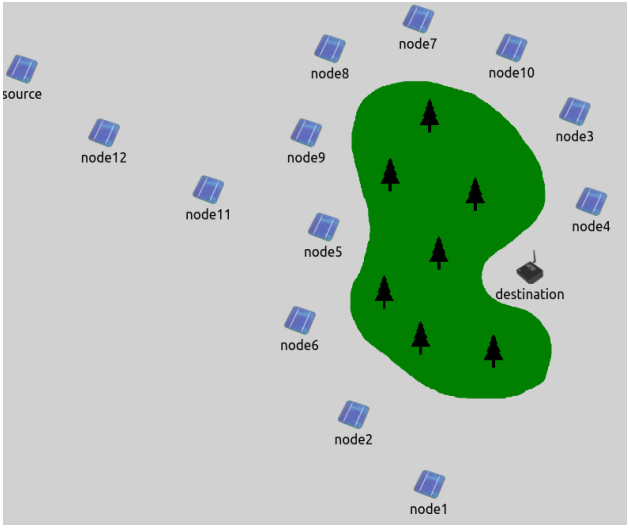

Figure 15: A Simulation scenario characcterization with 12 nodes

5. RESULTS AND DISCUSSIONS

A comparative simulation of conventional and location-position enhanced algorithm of Zone Routing Protocol (ZRP) was conducted on data packets received successfully, average data packets delay, data packets drop rate and data packet general throughput. It is paramount, nonetheless to note that simulation parameters are elementary. This was done purposively because there are no similar studies on which to build. In the future, studies may build on the findings of this research to include more advanced parameters such as nodes' density, power consumption, and transmission noise. Figure 16 represents the first rendering of the position-location enhanced simulator. The positions of the mobile devices are selected randomly.

Figure 17 represents the first test run screen shot. The approximation of the centralized database is at the center of the node. For example, the central server could be at host or node 42.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 145-154, 2022, ISSN:-2319–8656
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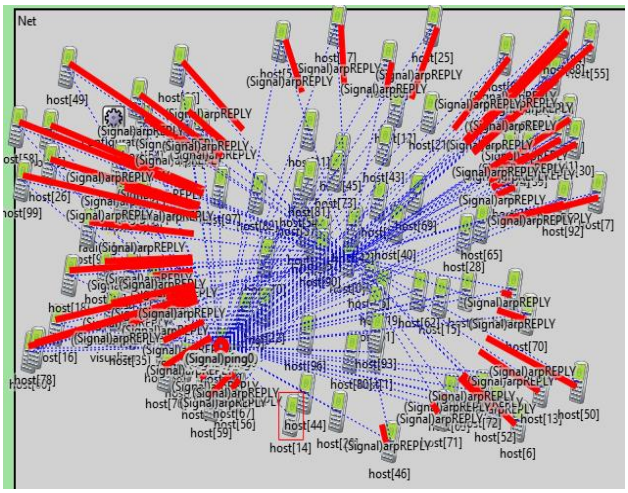

Figure 18: Initial Instance of Signal Transmission

Table 1: Preliminary elementary parameters

Elementary Parameter	**Metric Value**
Number of simulated nodes/devices	100
Estimated Area of Simulation	500m*500m
Simulation data packet size	1024 bytes
Simulation duration	300s
Simulation frequency	50

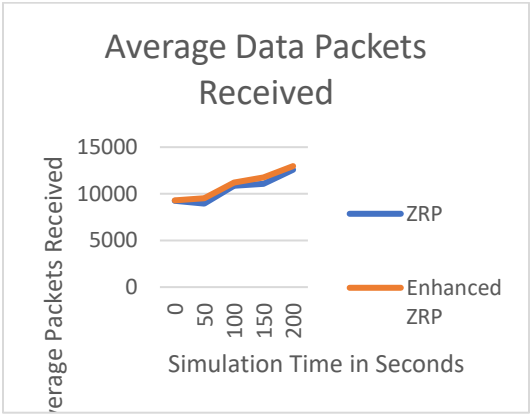

Figure 19: Average Packet Received

Average data packets are the packets that reached that were successfully delivered from the source node to the destination node. Received data packets is the difference between the packets sent from the source node and the data packets received at the destination node. The results are represented in chart figure 14. The following formular was used to arrive at the results represented in figure 14. However, average data packets received does not provide a detailed explanation between the data packets sent, the data packets lost and the data packets successfully received.

$$Average\ Packets\ Received = (Source\ Transmitted\ Packets - Destination\ Received\ Packets) \quad (3)$$

From the average data packets received successfully, it is possible to calculate the Packets Delivery Ratio (PDR). Such a ratio offers a mathematical representation of extent of data packets loss and the overall quantitative representation of the association among the data packets transmitted effectively and the initial data packets sent from the source node. But because there is insufficient studies on overhead reduction in ZRP, this study uses basic analysis of parameters. Ratio to represent successfully delivered data packets is realized by using the following formula.

$$PDR = \frac{Packets\ Succeffuly\ Received}{Packets\ Successfully\ Sent} \quad (4)$$

A high PDR—more than half, indicates that the network loses less data packets, thus an indication of efficiency. The optimal ration should be 1:1, whereby for every data packet received, there is an equal number of packets sent. A lower PDR, on the other hand, siginifies a possibly flawed network with a big data packets dropage. Consequently, network engineers and administrators must strive to realize the highest PDR possible.

Based on the simulation results, location-position enhanced ZRP outperforms traditional ZRP, however with small but steady margin. Although the differences form the curves may not seem large, its cumulative effects can be enormous in large networks. As the number of nodes increases, the seemingly subtle difference adds to augment effieciency. Results analysis and the overall cumulative principle hold true in other basic scalar parameters as shown in figures 15, 16 and 17.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 145-154, 2022, ISSN:-2319–8656
DOI:10.7753/IJCATR1104.1007

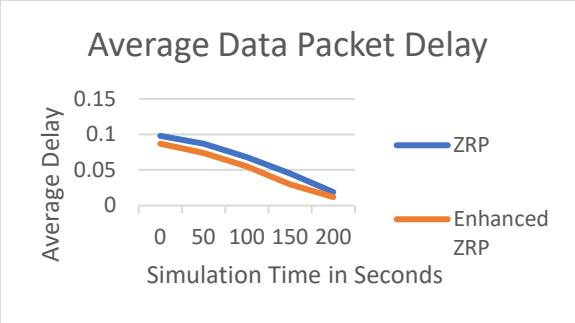

Figure 20: Average Delay

Average delay is the duration or time taken by a data packet from the source node to the destination node. An effective network should expose data packet to the minimal delay. That is, the time taken to successfully transmit a data packet from the source node to the destination node should be negligible as possible. High delay in data packets transmissions means that few data packets are delivered per unit time. This is so because a data packet takes more time to move from the source node to the destination node. Indeed, average delay in indirectly proportional to the overall data packets throughput. Once the delay is up, the general data packets throughput goes down. Data delivery delay can be caused by various network parameters. Some of the factors causing delay can be attributed to either the network topology or the or technical failure in the network. In most cases, data packets delay occurs in the network layer of the OSI model. Rarely does the Transport Layer affects the delay of data packets. For instance, a faulty or malfunctioning Address Resolution Protocol (ARP) can cause delay in data packets delivery.

However, data packets delivery delay can be caused by a fault in either Transport or Network layers. A faulty in both layers can also cause heighted delay in data packets delivery. Some of the network factors causing delay in data packets delivery include packets congestion, network topological mishaps, network technical faults, inept and low network capacities. To obtain average delay, the initial packet transmission time (IPTT) is subtracted from eventual packets reception time (EPTM). The resulting difference is then distributed among the number of packets received successfully at the eventual packet reception time. Average Packets Delay (APD) metric is measured by using the following formula:

$$APD = \frac{(EPTM) - (IPTT)}{Successfully\ Received\ Data\ Packets} \quad (5)$$

Figure 14 indicates a consistent less data packets delay in location-position enhanced ZRP. The reduced data packets delay suggests that as a result of inclusion of location-position information in ZRP algorithm, overlapping is minimized. With overlapping of zones minimized, the associated overhead power is likely to go down, hence increasing the routing efficiency of ZRP. Absence of overlapping in ZRP augments its ability and routing robustness. It is paramount to always keep in mind that due to combining both reactive and proactive properties of routing, ZRP is an already relatively sturdy routing protocol. A minimization of overlapping and overhead, it serves to only add more routing efficiency to ZRP.

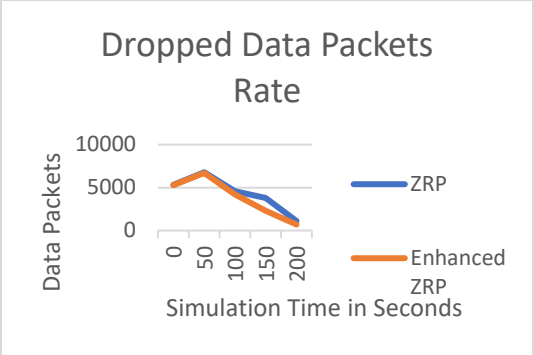

Figure 21: Data Packets Dropped

Data packets dropped is used to determine the packets lost during data transmission from the source node to the destnination node. Data packets loss is particularly critical because it is a possible indication of a defective network configuration or technical failure within the network. Loss of data packets can occur either in Transport or Netwok layers of the OSI models. Packets loss can also take place in both of the layers. No level of packets droppage is acceptable in a network. Any error message from the Internet Control Message Protocol (ICMP) is an indication of an incomplete delivery of the sent message. Incomplete received message affects the flow of communication by introducung uncessary unclarity.

In figure 15, the position-location enhanced ZRP consistently outperforms the traditional ZRP in the number of data packets dropped. The difference in the data packets droppage is attributable to the inclusion of the position-location information in the algorithm of ZRP. Inclusion of location-aware information ehnaces the accuracy of route discovery in ZRP. Such precision augments the overall delivery of data packets from the source to the destination. Some of the causes of data packet delivery delay include retransmission re-quests, broadcasting/transmission buffer, general signal latency or route discovery process.

Calculation of the data packets droppage rate is achieved by subtracting the number of pakcets succeffully transmitted from the source node from the number of data packets successfully received at the destination node. The difference between two metrics is then distributed over the time period from initiatial transmission to the eventual data packets reception at the destination node.

International Journal of Computer Applications Technology and Research
Volume 11–Issue 04, 145-154, 2022, ISSN:-2319–8656
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Data Packets Drop Rate
= (Successfully Eventual Received Packets
− Successfully Initial Transmitted Packets)
/(Transmission Time) (6)

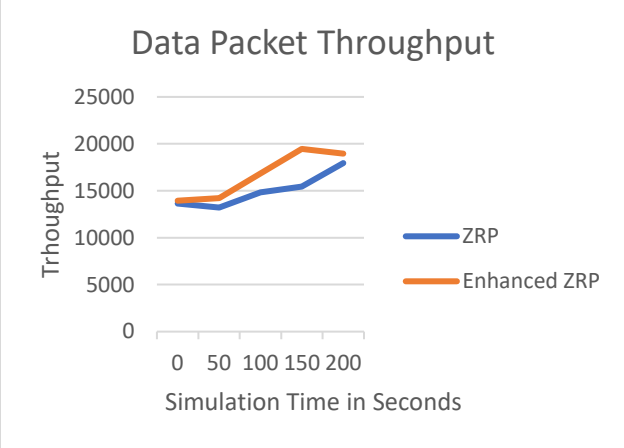

Figure 22: Data Packets Throughput

Data packets throughput represents the overall performance of a network over a period of time. Indeed, data packets throughput can be viewed as a summary of other basic scalar parameters such as delay, delivery and data packets drop rates. A combination of these metrics provides the overall performance of the network, measurable on data packets throughput. A low data packets through put may result from either of the issues associated with the outlined factors. An increased delivery delay due to congestion, for instance, may lower the general ultimate data throughput. Oppositely, a high packets throughput is an indication of maximized operationalization of other variables such as delay and drop rates. The metric measurement of data packets throughput is megabits per second (mbps) and lately gigabits per second (Gbps). Based on figure 17, a position-location enhanced ZRP consistently outperforms the conventional ZRP. Noticeably, however, the difference in the overall data packet throughput reduce after 175th second of simulation. Afterwards, the performance effectiveness of the two routing protocols begin to converge and become similar.

6. CONCLUSION AND RECOMMENDATIONS

This study proposes a technique to enhance ZRP through Scheme 1 of LAR. This is achieved by replacing the proactive algorithm code of IARP of ZRP with algorithm code of Scheme 1 of LAR. By doing so, the zones overlapping is eliminated, thus reduced overhead. The enhanced ZRP algorithm outperforms the traditional ZRP in the number of successfully delivered data packets, delay in delivery of data packets, the rate of data packets droppage and the general throughput of data packets. From the simulation results, it is clear that position-location enhanced ZRP outperforms the conventional ZRP on key basic scalar metrics. This is an indication of possible reduction of the zone overlaps during routing.

Inclusion of physical geographical information as a supplement to augments precision in the location of a node in a network. Increased precision of location of a node in a MANET network improves the efficiency of route discovery process within the IARP part of ZRP. The selected metrics include; data packet throughput, delay, and the number of data packets dropped. Generally, due to this enhanced performance, the location-position ZRP experiences less overhead as a result of minimized overlapping in routing zones. Such simulation results is a further prove that various properties of MANET routing protocols can be combined to produce supplementary effects in performance. Consequently, it is possible to create robust routing by combining favorable routing traits from various classes of protocols. For instance, hybrid routing can be improved by borrowing advantageous routing characteristics from location-aided routing.

However, due to limited number of studies examining combinational effects of MANETs routing properties, this research is limited to basic scalar parameters of delivery, delay, drop rate and general data packets output. The metric variables of the simulation were fixed on area and the number of nodes or devices. Therefore, it is suggested that more similar studies be conducted to include other intricate parameters such as jitter and power consumption. Security is also an area of MANETs that requires thoughtful inspection. Upon combining various aspects of MANET routing protocols, it is paramount to investigate some of the security effects that may result from such exercises.

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