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Service Audit in Filling Annual tax Return Using The Cobit 5 Framework at Tabanan Primary Tax service Office

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Abstract: An application of information technology in a company is important in order to make the company better. The information technology can support the achievement of the company's strategic plan to be aligned with its vision, mission and goals. Tabanan Primary Tax Service Office is a company as the example of the application of information technology for this research. The application in that company needs to be regulated, therefore it can be put to good use. In regulating information technology, an audit is needed which aims to evaluate and ensure compliance with the objective approach of a standard. The service audit in filing annual tax returns by using the COBIT 5 framework at the Tabanan Primary Tax Service Office is a form of audit to find out the IT processes that exist in the office. This audit was conducted to determine the level of maturity of the existing IT processes in the service of filing annual tax returns, whether it has been used properly and optimally based on COBIT 5. The audit analysis process performed to obtain capability results, such as the DSS 02, DSS 03, DSS 05, and APO 12 domains. Recommendations and suggestions for improvement of the results obtained are done using the COBIT 5 standard.

Keywords: Information Technology, Tabanan Primary Tax Service Office, COBIT 5.

1. INTRODUCTION

Information systems in a company or organization must be implemented because it has a positive impact and can improve performance to support business processes. The accuracy and speed of information are needed to help the decision making process, especially the strategic one.

The Primary Tax Service Office is a work unit of the Directorate General of Taxation that performs services in the field of taxation. Taxpayers have annual obligations, namely Annual Tax Return which is a tax report regarding the calculation, tax payment, object or non-object tax as well as the rights and obligations in accordance with the provisions submitted to the Indonesian government through the Directorate General of Taxation. All taxes are regulated by the Law of the Republic of Indonesia Number 36 of 2008. One of the information systems exist in the Primary Tax Service Office is E-Filing, which is an information system application that can be used by taxpayers in filing data input of annual tax return. There are some problems that often occur due to the negligence of the recording operator and the error of reporting data from the taxpayer, such as the error of taxpayer data input, loss of taxpayer data, miscalculation between the system and manual calculation, stacking of tax paper that has not been recorded by the operator. Therefore, an audit of all aspects related to the E-Filing information system is required.

An information system audit is developed with the aim of avoiding fraud and knowing the extent to which the implementation of the system is in accordance with the objectives, as the result a good governance is created. A method used in conducting the information system audit process is the COBIT (Control Objective for Information and Related Technology) framework. The COBIT framework was chosen because it provides practice standards of information technology management and internationally accepted references. In addition, it presents steps that are easily accepted and understood by auditors, managers, and system users in utilizing the application of information technology in an organization. The information systems management in E-Filing can use the COBIT framework, because it helps to fulfill the various management needs of information by bridging the gap between business risk, control and technical issues[1].

2. LITERATURE REVIEW

A previous study about information technology audit by using the COBIT 5 framework has previously been developed for state electricity companies entitled "Audit Capability EAM using COBIT 5 and ISO 55002 in State Electricity Companies" by Ni Kadek Ayu Widya Utami. It explains that the audit capability is performed to determine the maturity of the system and the condition of existing management, as well as to provide recommendations for improvement using COBIT 5 and ISO 55002 [2].

I Wayan Prasada Bharaditya has also conducted a research related to information technology audits for cooperative management by using the Cobit 5 framework. The study entitled "Internal Control Improvement for Creating Good Governance" explains about information technology audits performed on cooperatives to overcome problems or critical points and to support the achievement of optimal information technology governance by using the COBIT framework [3].

3. RESEARCH METHODS

The research method is the basic stages performed in conducting a research. It aims to make the research process more organized, systematic, controlled and directed. Planning in a study is needed, therefore it is directed and has a right target.

3.1 The Stages of the Information Technology Audit Process

The process stages are conducted, therefore the audit process is performed systematically and on target. The stages of the service audit process in filing annual tax returns at the Tabanan Primary Tax Service Office by using the COBIT 5 framework consists of 8 main stages. The stages are shown in Figure 1.

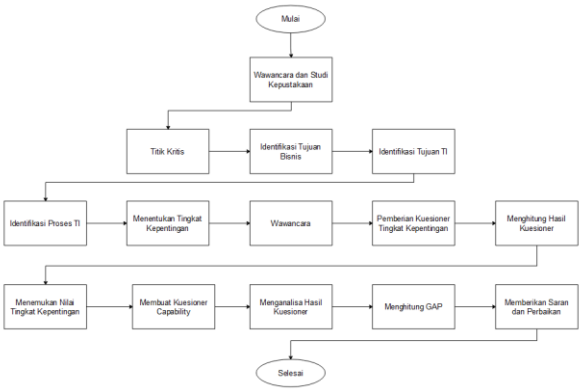

Figure. 1 Audit Research Stages

The service audit stages start from the interview and observation process which are the initial stages in conducting information technology audit research. It aims to find out and observe directly the problems that occur in the company [8]. Interviews are also applied to find out the critical points and objects that are performed by service audits. The second stage is the literature study, which done by collecting data and information through various libraries. The third stage is the core audit process which consists of identifying business objectives, IT objectives and IT processes. The identification of business processes aims to match the point of the company's problems with the business objectives that exist in the COBIT 5 framework. The identification of IT objectives aims to identify the results of business objectives with the IT objectives that are in COBIT 5. The identification of IT processes is the stage to find processes in the existing domain of the IT processes in COBIT 5 from the identification of IT objectives. The fourth stage is drafting importance level questionnaires that are obtained from the identification of IT processes and the company's problem points, as well as calculating the results of the importance level questionnaires to proceed to the next stage.

The fifth stage is compiling a capability questionnaire that is based on the results of the importance level questioners, problem points and the COBIT 5 framework. The sixth stage is the analysis of the results of the capability questionnaire to determine the level of the gap, therefore improvements can be made using the COBIT 5 framework. [6]

4. CONCEPTS AND THEORIES

This section contains concepts and theories that support the research. They are including the framework and capability level of COBIT 5. It will be discussed as follows.

4.1 Framework COBIT 5

COBIT (Control Objective for Information and Related Technology) is a standard of practice that contains guidelines for management practices and information technology governance in companies. It has gained recognition from all over the world as an effective tool for conducting assessments and implementations in supporting the achievement of information technology governance and management as well as IT capabilities [7]. The latest COBIT 5 which appeared on June 2012 discussed about the management of information technology in companies. It provides a comprehensive framework that helps companies to support the achievement of the information technology governance and technology assets (IT) [2]. COBIT is also a series of documentation and guidelines that lead to IT governance. Therefore, it helps auditors, management, and users to build a bridge between business risk, control needs, and technical issues. [3]

4.2 The Capability Level of COBIT 5

COBIT 5 introduces a capability model process which based on ISO / IEC 15504. The capability model is influenced by the organization's business objectives, operating environment and industry practices [4]. *It measures the performance of each governance process (EDM-based) or management process (PBRM based), and it can identify areas that need to be improved in performance.* The capability that can be achieved by each process consists of six levels, namely:

a. *Level 0 Incomplete Process* – The process is incomplete; the process was not implemented or failed to achieve its objectives. The level of Incomplete Process has little or no evidence of systematic achievement of the process objectives.

b. *Level 1 Performed Process (one attribute)* - The process has been performed; the implemented process has succeeded in achieving its objectives.

c. *Level 2 Managed Process (two attributes)* – The regular process (two attributes); the process has been performed and implemented in a more organized way (planned, monitored, and adjusted), and the output of the resulting process has been determined, controlled, and maintained to the maximum.

d. *Level 3 Established Process (two attributes)* - The process has been implemented by using predetermined SOP standards which are able to achieve the expected outcomes.

e. *Level 4 Predictable Process (two attributes)* - The process is performed by using established SOP standards. The process and results can be predicted within a specified time limit.

f. *Level 5 Optimizing Process (two attributes)* – The performance of the process continues to be improved on an ongoing basis in order to meet current and future business objectives.

Each level of capability can only be achieved when the results obtained at each level must at least be fully achieved with a score range of 85-1005. Furthermore, it can be continued at the next level.

5. RESULT AND DISCUSSION

5.1 Identification of Business Objectives

The identification of business processes is the initial stage performed in the information technology audit process. It is done by mapping a critical point towards the business objectives of the COBIT 5 framework. The business objectives of the COBIT 5 framework consist of 17 business objectives. The results of the mapping between critical points and business objectives can be seen in Table 1.

Table 1. Critical Mapping of Tabanan Primary Tax Service Offices with COBIT 5 Business Objectives

Source	Critical Point	No.	Business Objectives
Tabanan Primary Tax Service Offices	The taxpayers do not fill the data form of annual tax returns completely.	7	Availability of sustainable business services
	Filling out the form of annual tax returns is considered complicated by the taxpayer.	11	Optimization of business process functions
	The taxpayers complain of long queues when reporting the annual tax returns.	11	Optimization of business process functions
	The interface of the E-Filing application (online annual tax returns input) is hard to understand	11	Optimization of business process functions
	The taxpayers are in doubt to fill the tax return online via the E-Filing application and they chose to come directly to the office to fill it manually. As the result, it slows down the process of filing the annual tax return.	7.	Availability of sustainable business services
	The taxpayer data access by employees is still limited, hence it slows the process of checking taxpayer data that have dubious and incompatible data.	11	Optimization of business process functions

5.2 Identification of IT Objectives

The identification of IT objectives is performed in the information technology audit process after getting the results of mapping critical points with business objectives. The purpose of IT is used to determine the relationship between the critical point with IT objectives. Mapping business goals with IT goals can be seen in Table 2.

Table 2. Mapping Business Goals with IT Goals

No.	Business Objectives	IT Objectives
7	Availability of sustainable business services	4, 10, 14
11	Optimization of business process functions	7, 12

The mapping of business objectives with IT objectives can be seen in Table 2. The results of the IT objectives mapping obtained are numbers 4, 7, 10, 12 and 14 based on the COBIT 5 framework. An explanation of each IT goal is shown in Table 3.

Table 3. The explanation of IT Objectives

No.	IT objective obtained
4	Dealing with IT issues that is related to business risk
7	Delivering IT services that suit business needs.
10	Information security, infrastructure processing and applications.
12	Empowerment and support of business processes by integrating applications and technology into business processes.
14	Availability of reliable and useful information for decision making.

The explanation of the results of IT objectives can be seen in Table 3. From the results of mapping IT objectives with business objectives, there were 5 IT objectives obtained with an explanation in each of the process. Then, the objective of IT is used to map the IT process, therefore the results of the IT process focus on the company's critical points.

5.3 Identification of IT Process

The identification of IT processes is performed in the information technology audit process after getting the results of mapping business objectives with IT objectives. Mapping to the IT process is used to determine the relationship between IT objectives and the IT process by selecting a domain based on the COBIT 5 framework as shown in Table 4.

Table 4. Mapping IT Objectives with IT Process

IT Objectives		IT Process				
		EDM	APO	BAI	DSS	MEA
4	Dealing with IT issues related to business risk		12 13	06	01 02 03 04 05 06	01 02
7	Delivering IT services that suit business needs.	05	02 08 09 11	02 03 04 06	01 02 03 04 06	01

10	Information security, infrastructure processing and applications.		12 13	06	05	
12	Empowerment and support of business processes by integrating applications and technology into business processes.		08	02		
14	Availability of reliable and useful information for decision making.		09 13	04 10	03 04	

The mapping of IT objectives with IT processes is shown in Table 4. From the mapping results obtained, there were 20 out of 37 IT processes based on the COBIT 5 framework.

5.4 Determination of the RACI Chart

The determination of level of importance respondents is done by selecting respondents who have an interest in the business process of filing annual tax returns. Determining the respondents who are given the importance level questionnaire is done by making RACI chart. The RACI chart is used to find out the duties and responsibilities of each position in a job. The results of determining The RACI Chart can be seen in Table 5.

Table 5. *RACI Chart* of Level of Importance Determination

RACI	**Entity**					
R= Responsible (A person who does an activity) **A = Accountable (**A person who is responsible and has an authority to decide on a case**)** **C = Consult (**A person whose feedback or suggestions are needed and contribute to the activity**)** **I = Inform (**A people who needs to know the results of a decision or action**)**	Head office	Head of Service	Head of General Sub Division	Head of Data and Information Processing	Account Representative	Head of Supervision and Consultation
Coordinating the implementation of Annual Tax Returns research that is submitted beyond the deadline and a research in connection with the Annual Tax Returns that was not submitted.	R	I	I	I	I	I
Doing the preparation of taking the form of an Annual Income Tax Return along with the electronic application of Annual Income Tax Return by the Taxpayer, administration of the Annual Tax Return that has been received back, and the provision of Tax Object Notification	A	R	I	I	I	I
Developing a draft concept for improving SOPs in the Tax Service Office environment that is oriented to the quality assurance system.	R	I	A	I	I	I
Performing a recording, management, improvement, and utilization of tax data both systemically and manually, as well as implementing tax data protection.	A	I	R	I	I	I
Examining the completeness of the Annual Tax Returns and the terms of delivering the correction of it.	A	I	I	R	I	I
Conducting taxation technical guidance and consultation to the public, taxpayers or their proxies directly and indirectly	A	I	I	I	R	I

5.5 Importance Level Questionnaire

The importance level questionnaire is used to determine the level of importance that is part of the IT process details to support the IT process in a company. The list of questionnaire statements are determined based on the results of the mapping of IT processes and the company's critical points. The design of the importance level questionnaire can be seen in Table 6.

Table 6. Importance Level Questionnaire

No	IT Process					
1	(EDM 05) Ensuring transparency in company performance, conformity measurement and reporting, therefore the relationship between stakeholders is effective and in time.					
	The Level of Importance	STP	TP	CP	P	SP
2	(APO 2) Aligning strategic IT plans with business objectives, and communicating those objectives, therefore they can be understood by all stakeholders.					
	The Level of Importance	STP	TP	CP	P	SP
3	(APO 8) Ensuring transparency between business					

	objectives and the information technology application, therefore it can run well and achieve optimal goals.					
	The Level of Importance	STP	TP	CP	P	SP

The importance level questionnaire consisted of 20 statements related to the company's critical point and the IT process of mapping results that had been carried out previously. It aims to find out the opinion of the top brass of the organization regarding the importance of each IT process. There are 5 choices of the level of importance that must be answered by the respondent, such as very unimportant (STP), unimportant (TP), quite important (CP), important (P) and very important (SP).

5.6 Capability Level Questionnaire

The capability level questionnaire contains a statement about the IT process domain that has been adjusted to the critical point and documents from COBIT 5. It aims to determine the maturity of each domain that was given the statement. The capability level questionnaire was given to the company's top level management. The capability level questionnaire design can be seen in Table 7.

Table 7. Example of Capability Level Questionnaire

No.	Level	
		Point of Problem: Taxpayer data access by employees is still limited, hence it slows the process of checking taxpayer data that has dubious and incompatible data.
		Process: DSS 05 Protecting company information to maintain the level of information security risks that can be accepted by companies in accordance with security policies. Establishing and maintaining information security and access rights, as well as conducting security monitoring.
1.	1.1	a) Network and communication security meets the needs of the company. b) Information is processed, stored and disseminated through protected devices. c) All users or employees have a personal account and access rights in business processes. d) Protecting information from unauthorized access, breakdown, and interference during the process. e) Electronic information is well-protected when stored, transferred or destroyed.
2.	2.1	a) The purpose of a process performance is identified b) The performance of the planned and supervised process c) The performance of the process that is changed to meet the needs d) The responsibility and authority to carry out the process are defined, assessed and communicated. e) Resources and information that are needed for the process are defined, assessed and communicated.
3.	2.2	a) The need for work from a process is defined b) The need for documentation and control of work is defined c) Work products are properly identified, registered and controlled

The capability level questionnaire design in Table 7 shows the questionnaire in the DSS 05 domain. Each domain has a statement that must be filled in by the respondent by giving a value of 0-100. The questionnaire results are calculated based on the average at each level of the capability questionnaire.

5.7 Maturity Level Analysis

The analysis of maturity level is used to determine gaps in each IT process. The gap is obtained by looking at the current capability and expected capability in each of the capability questionnaires of IT process. Table 8 shows the results of capability level maturity.

Table 8. The results of Capability Level Gaps

IT Process	*Current Capability* (CC)	*Expected Capability* (EC)	GAP (EC – CC)
DSS02	3	5	2
DSS03	3	5	2
DSS05	3	5	2
APO12	3	5	2

Table 8 is a table of the results of the current capability level gap where it is obtained from the results of the Current Capability (CC) questionnaire, the capability expected by the organization or company in table 4.17 (Expected Capability (EC) and the gap level of expected capability minus current capability.

5.8 Recommendations for Improvement

Analysis of recommendations for improvement is given to the 4 capability domains. Existing condition, expected condition and recommendations for improvement are given based on the COBIT 5 framework. The analysis of recommendations for improvement can be seen in Table 9.

Existing Condition	Expected Condition	Recommendation
The interface of e-filing application is not easily understood by taxpayers (DSS 02)	There is an improvement in the e-filing application interface in order to facilitate taxpayers in filing the annual tax return, as the result there is no error in filing the data	It is recommended to the Tabanan Primary Tax Service Office to change the e-filing application interface into the one that can be easily understood by taxpayers as users. In addition, creating user guides that can help taxpayers if they have difficulty in understanding the filing form.
Long queues during the	There is an evaluation of the	It is recommended to

Annual Tax Return reporting process complained by taxpayers. (DSS 03)	problems that cause long queues during the Annual Tax Returns reporting process which takes a long time.	the Tabanan Primary Tax Service Office to do an evaluation of the problems that cause long queues. In addition, conducting training for employees who handle the Annual Tax Returns reporting process to be able to work more quickly and efficiently.
Taxpayer data access by employees is still limited, hence it slows the process of checking taxpayer data that is beyond the limits (DSS 05)	There is an evaluation of the taxpayer's data access rights of employees in order to speed up the process of checking taxpayer data that beyond the limits, hence it speeds up the input process	It is recommended to the Tabanan Primary Tax Service Office to do an evaluation of the problems in the process of checking taxpayer data in order to make the input process to be faster and more efficient.

6. CONCLUSION

As the final results of the service audit in filing annual tax returns at the Tabanan Primary Tax Service Office by using the COBIT 5 framework, there are four domains that become the evaluation points, namely DSS 02, DSS 03, DSS 05, and APO 12 with current capability at level 3 (established process), and all domains have expected capability at level 5 (optimizing process). In addition, there are recommendations for improvement and expected conditions given to achieve expected capability at level 5 with the PAM Using COBIT 5 Toolkit-Self Assessment Templates as additional suggestions and improvements.

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Adaptive Histogram Equalization to Increase the Percentage of Face Recognition

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Abstract: Biometric system is a self-recognition technology using body parts or human behavior, one of which is the face. The face recognition system is designed to recognize the user by matching the biometric characteristics of the user to the biometric characteristics that have been stored in the database. Many methods can be applied to face recognition systems, such as the Eigenface method that adapts the Principal Component Analysis algorithm. The Eigenface method has a weakness, which is very dependent on the intensity of light. The further the difference in light intensity on the training image and test image, the smaller the percentage of successful face recognition. The adaptive histogram equalization method can be used to overcome the weaknesses of the Eigenface method. The purpose of using the adaptive histogram equalization method is to generalize the intensity of gray values in the Grayscale image and increase the contrast of the image, so that facial features can be further highlighted. The results showed that the use of adaptive histogram equalization can increase the percentage of successful face recognition.

Keywords: Biometric, Face Recognition, Eigenface, PCA, Adaptive Histogram Equalization

1. INTRODUCTION

Biometrics is a self-recognition technology using body parts or human behavior, one of which is the face. The face recognition system applies biometrics to recognize someone's identity automatically using computer technology. The system will find and match a person's identity with a reference database that has been prepared previously through the process of data collection. The advantages of using faces in biometrics are that they are not easily erased or lost, are easy to apply, and have different characteristics for each person. Many methods can be applied to face recognition systems, such as the Fisherface and Eigenface methods. This study uses the Eigenface method that adapts the PCA algorithm (Principal Component Analysis). The Eigenface method has a weakness, which is very dependent on the intensity of light. The further the difference in the intensity of light in the training image and the test image, the smaller the percentage of successful face recognition. The purpose of this study is to increase the percentage of the success of face recognition systems by applying adaptive histogram equalization. The first stage is preprocessing, then, the image will go through the histogram equalization stage to equalize the light intensity in each image, before finally extracting the features by the Eigenface method.

2. LITERATURE REVIEW

Arunalatha studied the use of the FCHE (Face Classification Using Histogram Equalization) method in face recognition systems. This method is used to overcome weaknesses such as motion blur and lighting that affect recognition accuracy. The method tested on the FERET, ORL, Extended YALE, and JAFEE databases; concludes that the FCHE method is better than the conventional CIRLRC method (Conventional and Inverse Representation based Linear Regression Classification) [1].

Other study by Al-Shayea discussed the application of histogram equalization in face recognition systems. First, preprocessing is performed on the facial image taken, then histogram equalization is performed, then extraction of image features. Histogram equalization method is applied to the face database (face94). As a result, faces are well recognized, and there is an increase in the recognition rate to the effective value based on the False Accept Rate (FAR) and False Match Rate (FMR) [2].

Sonam, who studies histogram equalization, stated that this method is not the best method for increasing contrast because the average brightness of the output image is significantly different from the input image. The method developed from histogram equalization, such as BBHE (Brightness Preserving Bi-Histogram Equalization) for contrast enhancement and DSIHE (Dualistic Sub Image Histogram Equalization) which divides the image histogram into two parts based on the average input and median, then equalizes each sub histogram. Both of these development methods have several advantages over the general histogram equalization method in the contrast enhancement section [3].

Research that has been done generally applies the method of histogram equalization in the face recognition system to find the advantages of using this method. The results of histogram equalization can overcome weaknesses such as motion blur and lighting, so as to increase the accuracy of the recognition level. Research by Sonam shows that the use of methods developed from the histogram equalization method, such as BBHE and DSIHE, resulted in a better level of recognition. The research that will be carried out is the application of the development method of the histogram equalization method, namely adaptive histogram equalization, to overcome the weakness of the Eigenface method in light intensity. The application of adaptive histogram equalization can equalize the contrast and gray level of a face image, so that the percentage of successful face recognition also increases.

3. RESEARCH METHODOLOGY

3.1 Face Recognition System Overview

The face recognition system is created using the Python programming language and the OpenCV library. The CV

function in OpenCV contains image processing and camera calibration methods. Computational geometry functions also lie in this function [4]. In general, there are two processes that run on the face recognition system, the user registration process and the user recognition process.

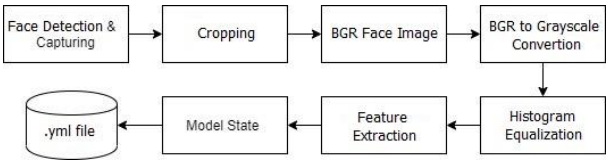

Figure 1. User Registration

Figure 1 is the stage of registering the user's face image into a face recognition system. The user registration phase starts from the face detection process, then the capturing process to get the user's face image, then the face image is cropped to get certain facial features, namely; eyebrows, eyes and nose. BGR (Blue, Green, Red) face images that have gone through the cropping process are then converted to Grayscale face images to minimize or disguise noise in the image, furthermore it can make it easier to distinguish the color intensity of the image. The next step is to apply adaptive histogram equalization to equalize gray levels and enhance image contrast so that facial features can be further highlighted. The last step is feature extraction by the Eigenface method so that the eigenvalue and eigenvector are stored as state models in the .yml format file.
The user recognition process is a process to test whether the system can recognize the user by comparing the model state of an image with model state of the images that has been stored in the .yml format file.

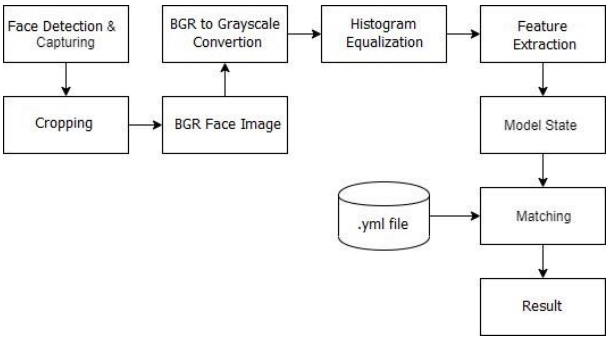

Figure 2. User Recognition

Figure 2 is the stage of user recognition in the face recognition system. The user recognition stage is the same as the user registration stage of the face detection process, capturing process, then cropping to get a BGR face image. This image is then converted to a Grayscale face image so that adaptive histogram equalization can be applied. The next step is feature extraction by the Eigenface method. The results of the feature extraction in the form of a model state are then compared with the model state that has been saved in a file with the .yml format at the time of user registration. The system will display a notification in the form of "You Are Not a User!" If the system does not recognize the user, and "Welcome!" If the system successfully recognizes the user. Step by step in the face recognition system will be explained as follows.

3.2 Preprocessing

Preprocessing is the initial process that will transform input data into data with an appropriate format and is ready to be processed [5]. Some examples of stages carried out in the preprocessing process, namely improving image quality (contrast, brightness, etc.), eliminating noise, image improvement (image restoration), transformation (image transformation), and determining the part of the image to be observed. Here are the initial images taken in 3 different lux ranges, namely the lux range 0-800, the lux range 801-1600 and the lux range 1601-2400.

(a) Lux 0-800 (b) Lux 801-1200 (c) Lux 1201-2400

Figure 3. User's Face Image in 3 Different Lux Spans

Figure 3 shows the user's image in different light intensity ranges. All three images have gone through the process of cropping to get features, eyes and nose. The result of cropping is a BGR image with a size of 225x225 pixels. BGR (Blue, Green, Red) is the default color of the OpenCV library. The next stage is the conversion of BGR images into Grayscale images to simplify the image model, simplify the segmentation process and to disguise the noise that exists in the image. Grayscale image is an image that only has gray level color. The gray colors in Grayscale images consist of B (Blue), G (Green), R (Red) colors that have the same intensity, so Grayscale images only require a single intensity value compared to a color image that requires three intensities for each pixel.

(a) Lux 0-800 (b) Lux 801-1200 (c) Lux 1201-2400

Figure 4. BGR User Image That Has Been Converted to A Grayscale Image

The process of converting BGR images into Grayscale images is expected to minimize or disguise noise in the image, also to make it easier to distinguish the intensity of colors in the image. Changing an image to Grayscale can be done by taking all pixels in the image, then the color of each pixel will be given information about 3 basic colors namely Blue, Green and Red (BGR). These three basic colors will be added together then divided by three to get an average value. This average value will be used to give color to the image pixels, so that the color becomes Grayscale, the three basic colors of a pixel will be set to be an average value.

3.3 Histogram Equalization

The Eigenface method has a weakness, which is light intensity. The difference in the intensity of light in the image will affect the eigenvalue and eigenvector generated in the feature extraction process. The greater the difference in light intensity at the time of user registration and at user recognition, the less chance the system will recognize the user correctly. Adaptive histogram equalization can overcome this weakness. This method aims to generalize the intensity of gray values in Grayscale images and increase the contrast of Grayscale images. The following are the results of applying adaptive histogram equalization.

(a) Lux 0-800 (b) Lux 801-1200 (c) Lux 1201-2400

Figure 5. Image of Users That Have Experienced Histogram Equalization Process

Figure 5 is the result of the image after adaptive histogram equalization is applied. In adaptive histogram equalization, the contrast value limit can be determined by itself (40 is the default value in OpenCV). This adaptive histogram equalization method in OpenCV can be applied with the CLAHE (Contrast Limited Adaptive Histogram Equalization) function. In Figure 5, it appears that the image brightness level of the histogram equalization results is more evenly distributed than the image results only through the process of conversion into Grayscale images in Figure 4. The facial features to be taken namely eyebrows, eyes and nose also appear clearer due to the addition of contrast.

3.4 Feature Extraction

Feature extraction is a method to characterize objects in an image with the aim of recognizing the object [6]. Feature extraction aims to look for significant features in an image depending on intrinsic characteristics and application. This feature is obtained from differences in shape, texture, size, intensity, statistical properties, and so on. In the face recognition system, feature extraction is done by the Eigenface method, which is based on the PCA (Principal Component Analysis) algorithm. The result of feature extraction is the eigenvalue and eigenvector which are stored in the form of a model state in the .yml file extension.

```
%YAML:1.0
---
opencv_eigenfaces:
   threshold: 1.7976931348623157e+308
   num_components: 56
   mean: !!opencv-matrix
      rows: 1
      cols: 50625
      dt: d
      data: [ 2.0225000000000000e+02, 2.0389285714285714e+02,
          2.0489285714285714e+02, 2.0569642857142856e+02,
          2.0712500000000000e+02, 2.0798214285714283e+02,
          2.0917857142857142e+02, 2.0928571428571428e+02,
          2.0939285714285714e+02, 2.1019642857142856e+02,
          2.1155357142857142e+02, 2.1285714285714283e+02,
          2.1426785714285714e+02, 2.1469642857142856e+02,
          2.1557142857142856e+02, 2.1651785714285714e+02,
          2.1732142857142856e+02, 2.1857142857142856e+02,
          2.1878571428571428e+02, 2.1914285714285714e+02,
          2.1967857142857142e+02, 2.2132142857142856e+02,
          2.2244642857142856e+02, 2.2317857142857142e+02,
          2.2364285714285714e+02, 2.2430357142857142e+02,
          2.2469642857142856e+02, 2.2496428571428569e+02,
          2.2528571428571428e+02, 2.2523214285714283e+02,
          1.9081678151607748e-02, -2.4435793806013920e-03,
          1.2086499350486361e+02, -3.9524186551183516e+02,
          -1.6316711342789199e+02, -1.0664697536476135e+03 ]
labels: !!opencv-matrix
   rows: 56
   cols: 1
   dt: i
   data: [ 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2,
       2, 3, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5,
       5, 6, 6, 6, 6, 6, 6, 6, 7, 7, 7, 7, 7, 7, 7 ]
labelsInfo:
   []
```

Figure 6. Model State of Feature Extraction Results

Figure 6 shows the result of feature extraction in the form of a model state stored in a .yml file extension. The state model of all images entering the system is stored in one array, which will be used when matching.

3.5 Matching

The matching process is only done at the user recognition stage (Figure 2). After the feature extraction results are obtained in the form of a model state, these results are then matched (matching) with the state model that has been previously stored in the .yml file through the registration process (Figure 1). The EigenFaceRecognition class in OpenCV has a predict function that is used to predict the similarity of matching results. This predict function has three parameters, namely src, label and confidence. Src is a predictive image, label is the label/ID of that image (can be seen at the bottom of the .yml file), and confidence is the difference between the previously saved model state and the model state that was inputted during the user recognition process. The confidence calculation is done using the Euclidean Distance method, which compares the vector values obtained with the vector image values in the database [7]. The lower the value of the calculation results, the more accurate the prediction results. The image that has the smallest distance value will be recognized as the user's face image.

4. CONCEPTS AND THEORIES

4.1 Biometric

The biometrics system is a self-recognition technology using human body parts or behavior. The biometrics system automatically recognizes a person's identity based on a biometrics feature by matching the person's biometrics features with the biometrics characteristics that have been stored in the database. The face is one part of the body that is used in the biometric system. Every individual in the world has a unique face, even two twins that cannot be distinguished by the human eyes [8].

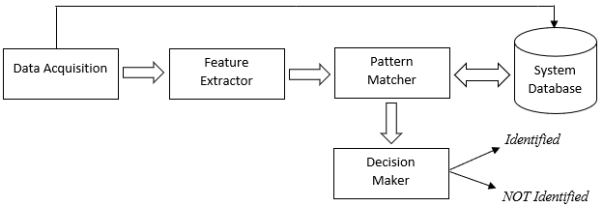

Figure 7. Biometric Identification Process

Biometric systems begin by obtaining biometric data from an individual, extracting feature sets from the obtained data, and comparing these feature sets with templates that have been set in the database. Biometric system design takes into account five things, namely cost, user acceptance and environmental constraints, accuracy, computational speed, and security [9].

4.2 Python and OpenCV

Python is a multi-purpose interpretative programming language with a design philosophy that focuses on the level of code readability. Python is claimed to be a language that combines capabilities, abilities, with very clear code syntax, and is equipped with large, standard and comprehensive library functionality. Python is also supported by a large community [10]. The Python programming language created by Guido van Rossum supports dynamic system types and automatic memory management, and has a large and comprehensive standard library.

Python has a very large standard library which certainly can ease the performance of users because they do not have to write all the code themselves. For example, if a user needs to connect Python with a MySQL database on a Web server, she or he can use the PyMySQL library and import PyMySQL. The standard library in Python has been tested and used by

many people, so it believes the user that the library will not damage the application that has been done [11].
OpenCV is one library that is supported by Python. OpenCV (Open Source Computer Vision) is a library of programming functions aimed at real-time computer vision. This library has more than 2500 optimized algorithms, which can be used to detect and recognize faces, identify objects, classify human actions in video, track camera movements, and track moving objects.

4.3 Eigenface Method

Eigenface is a way to extract relevant information from a face image, then convert it into a set of efficient codes and the face code is compared to a face database that has been coded similarly [12]. Eigenface is the principal component (important features) of the distribution of facial images obtained from eigenvectors. Eigenface is an algorithm based on Principal Component Analysis (PCA). PCA performs a covariant matrix calculation from a group of trained face images to obtain an eigenface. The eigenface will be the basis for calculating face distances that represent individual weight values that represent one or more facial images. This weight value is used to recognize the test face image by finding the distance value of the test face image weight with the training face image weight value. Calculation of the distance of the weight value is done by calculating the Euclidean Distance. Alan Brooks once developed a study comparing two algorithms, namely Eigenface and Fisherface. These researches are focused on whether changes in facial poses affect the accuracy of face recognition. A training database in the form of a photograph of a human face is used to train a face recognition system, after the training process is completed, an input image that is actually the same as one of the face images in the training phase but with a different pose. The system is also expected to have a minimum sensitivity to lighting. The system was developed with two algorithms, namely Eigenface and Fisherface, and compared the results. Both techniques produce satisfying results, but there are some differences. Eigenface has a simpler computational complexity than Fisherface. The Eigenface technique is also more sensitive to lighting compared to Fisherface [13].

4.4 Histogram Equalization

Image enhancement is the process of adjusting digital images such as removing noise, or sharpening or brightening images to facilitate identification of the main features of the image. One example of image enhancement is histogram equalization. Histogram equalization is a method in image processing that adjusts the contrast using the histogram of the image. This method usually increases the global contrast of an image and through this adjustment; the light intensity of the image can be better distributed on the histogram. This method allows areas with lower contrast to obtain higher contrast. Histogram equalization effectively distributes the highest intensity value. This method is useful in imagery with a background and foreground which are both bright or both dark [14].
Modifications of this method use many histograms at once, so called sub histograms, to emphasize contrast in one area rather than the entire image area; the example is adaptive histogram equalization. Adaptive histogram equalization has a contrast value limit that can be determined by itself (40 is the default value on OpenCV). This adaptive histogram equalization method in OpenCV can be applied with the CLAHE function (Contrast Limited Adaptive Histogram Equalization).

5. RESULT AND ANALYSIS

5.1 Histogram Results

The images tested are BGR images, BGR images that have been converted into Grayscale images, and Grayscale images that have gone through the histogram equalization process respectively in different lux ranges (units of light level), namely in the 0-800 lux range, the 801-1600 lux range and 1801-2400 lux range. Lux values are measured with the Lux Light Meter Android application.

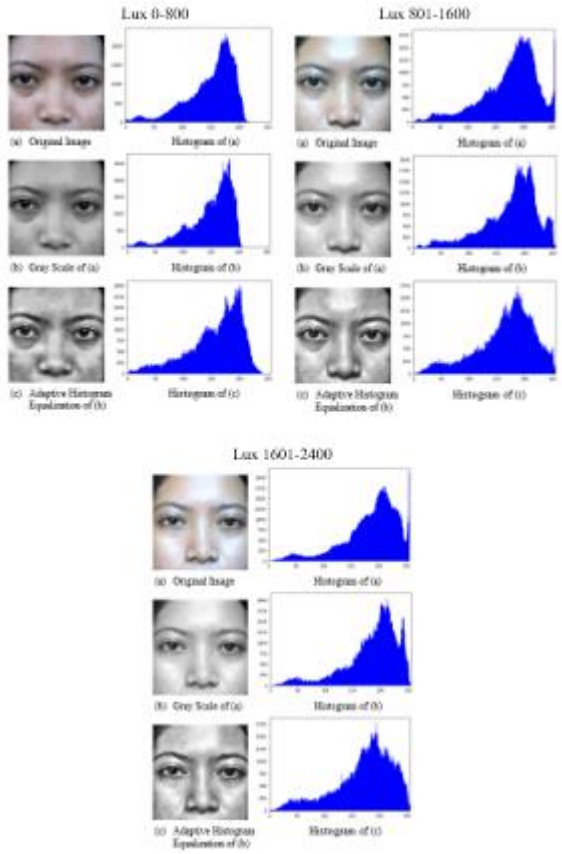

Figure 8. BGR Image Histogram, Grayscale Image and Histogram Equalization Image

Figure 8 shows the histogram of the BGR image, the BGR image that has been converted to a Grayscale image, and the Grayscale image through the histogram equalization process respectively in different lux ranges, namely in the 0-800 lux range, the 801-1600 lux range and the lux range 1801-2400. There are differences in the BGR image histogram, the Grayscale image, and the image that has gone through an equalization process. When compared to BGR images and Grayscale images, image histograms after applying adaptive histogram equalization are more even, and the facial features appear more clearly due to increased image contrast.

5.2 Results of the Face Recognition System Testing

First, there is a user registration with 10 people (each 1 image for each person) in light intensity with a range of 801-1600 lux. Tested with 10 (ten) face images in three environmental conditions with different light intensities, namely at 0-800 lux light intensity (range of light intensity in a dim room), 801-1600 lux (range of light intensity in a bright room), and 1601-2400 lux (range of light intensities in very bright rooms). Tests carried out a number of times, namely testing with BGR

face images that have been converted into Grayscale face images and testing with facial images that have gone through the process of histogram equalization.

Table 1. Grayscale Face Image Test Results

ID user	Lux 0 – 800	Lux 801 – 1600	Lux 1601 – 2400
1	FAILED	SUCCESS	FAILED
2	FAILED	SUCCESS	SUCCESS
3	SUCCESS	FAILED	FAILED
4	SUCCESS	SUCCESS	SUCCESS
5	FAILED	SUCCESS	SUCCESS
6	SUCCESS	FAILED	FAILED
7	SUCCESS	FAILED	FAILED
8	FAILED	SUCCESS	FAILED
9	SUCCESS	SUCCESS	FAILED
10	FAILED	FAILED	SUCCESS

Table 1 is the result of testing 10 Grayscale face images under environmental conditions with different light intensities. The results obtained from the test are in environments with light intensity of 0-800 lux (range of light intensity in a dim room), 5 out of 10 users have been identified correctly, while the remaining 5 are recognized as other users. In environments with light intensities of 801-1600 lux (range of light intensities in bright rooms), 6 out of 10 users are identified. Tests carried out in environments with a light intensity of 1601-2400 lux (range of light intensity in a very bright room), only 4 users out of 10 users were successfully identified.

Table 2. Facial Image Test Results that Have Been Through the Histogram Equalization Process

ID user	Lux 0 – 800	Lux 801 – 1600	Lux 1601 – 2400
1	SUCCESS	SUCCESS	FAILED
2	SUCCESS	FAILED	SUCCESS
3	SUCCESS	SUCCESS	FAILED
4	SUCCESS	SUCCESS	SUCCESS
5	SUCCESS	SUCCESS	SUCCESS
6	FAILED	SUCCESS	SUCCESS
7	SUCCESS	SUCCESS	SUCCESS
8	FAILED	FAILED	FAILED
9	SUCCESS	SUCCESS	SUCCESS
10	SUCCESS	SUCCESS	FAILED

Table 2 is the result of testing 10 face images that have gone through the process of histogram equalization in environmental conditions with different light intensities. It is known that histogram equalization is done to increase image contrast, so that facial features can be seen clearer. The results of the tests carried out are in environments with light intensity of 0-800 lux (average light intensity in the room), 8 out of 10 users have been identified correctly, while the remaining 2 are recognized as other users. Tests carried out in environments with light intensities of 801-1600 lux (range of light intensities in bright rooms), 8 out of 10 users have been identified. Tests carried out in environments with a light intensity of 1601-2400 lux (range of light intensity in a very bright room), 6 out of 10 users were successfully identified.

6. CONCLUSION

The Eigenface method used in face recognition systems has a weakness, namely the light intensity. The more similar the intensity of light at the time of user registration with the time of user introduction, the more accurate the results of the introduction. Weaknesses of the Eigenface method can be overcomed by applying adaptive histogram equalization. Histogram equalization is a method for adjusting the light intensity of an image by distributing it evenly on the histogram. This method allows areas with lower contrast to gain additional contrast, so as to highlight facial features that will be used in the feature extraction process by the Eigenface method. The last experiment in which face recognition testing of Grayscale's face image and face image after adaptive histogram equalization was applied, it was found that in the Lux 0-800 range, the percentage of images that had been identified increased from 50% to 80%. Experiments carried out in the lux range 801-1600, the percentage of success increased from 60% to 80%, while in the lux range 1601-2400, the percentage of success increased from 40% to 60%.

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A Planning Strategy of Charging Facilities Selection for Electric Vehicles

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Abstract: The path planning for Electric Vehicle (EV) charging enables the owner to reasonably select the charging facility. The charging facility is an important place for the EV to replenish the power. The balance of utilization rate of charging facilities is less considered in current researches, the deviation of the utilization rate of charging facilities will lead to some problems such as excessive load of charging facilities and traffic jams on surrounding roads. Therefore, this paper proposed the charging facility selection method (CFSM) for the path planning of EV. By considering the road traffic condition, CFSM selects charging facilities under the constraint of the shortest driving time of EVs and establishes the charging guidance model of EVs. We implement the proposed CFSM under the constructed EV simulation scenarios. The CFSM was compared with the method of selecting the nearest charging facility (NSCF) and the method of randomly selecting a charging facility (RSCF), and several experiments were performed. The experimental results show that the time utilization variance of CFSM is 95.8% lower than that of NCSF, and 95.1% lower than that of RSCF. Balance the utilization of charging facilities based on the shortest total vehicle running time.

Keywords: EVs; charging facilities; utilization; balance; total time

1. INTRODUCTION

With the pressure of the air pollution and energy crisis, the use of EVs will increase [1]. However, the battery capacity of an EV is limited, it is not possible to travel a long distance at a time and arrive destination within a limited amount of battery power, it is necessary to recharge the battery through a charging facility while traveling. Because of the limited number of charging facilities and the uneven geographical distribution [2], the vehicle needs to plan the charging path and select a reasonable charging facility to supplement the power.

At present, many domestic and foreign scholars have studied the choice of charging facilities. The choice of charging facilities is mainly divided into the following three aspects: (1) Select a charging facility based on the price of electricity at different charging facilities. Pustisek et al. [3] developed a smart contract through a charging station, requested charging auctions from various charging stations along the way, and selected a suitable charging facility according to the price set by the charging station. Peng Xu [4] By proposing a dynamic pricing system, using the price of different charging facilities to guide the owner to charge, Shu Su et al. [5] proposed charging path planning based on the floating pricing of the grid, Fang Cao et al.[6] proposed a charging floating service The optimization model of the fee guides EV users to charge more reasonably. Yinchi Shao et al. [7] used a dynamic electricity price demand function to establish a charging electricity price model. (2) Select a charging facility by considering the profit of the charging facility. In 2016, Ghosh et al. [8] proposed a menu-based V2G service pricing method based on the consideration of the profit of the charging station. In 2017, Ghosh et al. [9] established an optimization model with the operator's maximum profit as the objective function. A fixed profit pricing scheme is proposed to provide a fixed profit for charging stations. Liang Zhang et al. [10] established an orderly charging model for EVs in charging facilities to maximize the revenue of charging facilities. (3) Select the charging facility based on energy consumption, distance, and distribution network load. Xin Wang et al. [11] reduce the charging cost of EVs on the basis of optimizing the distribution network load, Jin Nie et al. [12] proposed that the charging price should be set reasonably, guide the EV to charge and discharge in an orderly manner, and reduce the

peak operating load of the power grid, Liao et al. [13] This paper proposes a new method based on C2C communication technology to calculate and determine the shortest path of minimum power consumption, and helps drivers find the nearest charging station. Shao et al. [14] ignored the queuing problem of the charging facility when selecting the charging facility, and assumed that the charging time was 30 min. Tan et al. [15] optimized the operation of the grid to minimize the daily charging cost, Lee et al. [16] proposed to increase the reception rate of vehicles in charging facilities through appointment services.

All of the above studies focus on the charging cost and the profit of the charging facility and select the charging facility with the lowest electricity price of the charging facility, stable distribution network load, and the nearest and farthest charging facilities. However, users have a lot of randomness when choosing a charging facility, so that most of the vehicles are concentrated in one charging facility for charging, and there will be problems such as excessive queuing time and road traffic jam around some charging facilities. Therefore, this paper balances the overall utilization rate of charging facilities based on the lowest total time cost. Under the premise of considering road traffic conditions, the EV charging strategy planning method (CFSM) is proposed, it is also compared with the nearest charging facility selection method (NSCF) and the random charging facility selection method (RSCF). The experimental results show that the CFSM method can reduce the user's time cost and balance the overall utilization of the charging facility.

This paper mainly has two contributions: First, the difficulty of road traffic will affect the travel time of electric vehicles. We propose a method to express the difficulty of road traffic, this method expresses the difficulty of road traffic by the actual moving distance, and can calculate the actual driving time of electric vehicles under different road traffic conditions. Second, we propose a method to measure the balance of charging facilities and design a method to guide the charging of electric vehicles with charging needs.

The rest of the paper is organized as follows: Section 2 establishes a charging guide model for electric vehicles. Section 3 describes the CFSM algorithm proposed in this paper in detail. Section 4 analyzes the experimental results. Section 5 summarizes the article.

2. EV CHARGING GUIDE MODEL

2.1 Traffic Impedance Model

The road traffic impedance is the degree of traffic difficulty of the vehicle passing through the whole road network, and the traffic situation is expressed by the distance traveled by the EV. That is, the moving distance of the EV is equal to the product of the impedance coefficient and the actual distance.

$$R_{SD} = \overline{V} / V_{SD} \tag{1}$$

In formula (1), $\overline{V}$ is the average speed of the vehicle traveling from the start point S to the end point D, V_{SD} is the average speed of all the vehicles in the road, R_{SD} is the road traffic impedance coefficient.

In real life, road traffic conditions can affect the driving time of EVs. In this experiment, in order to better simulate road traffic conditions, we set different impedance coefficients to represent road traffic conditions, as shown in Table 1.

Table 1. Impedance coefficient

RSD value	[0,0.5)	[0.5,1)	[1,1.5)	[1.5,2]
Road traffic situation	Smooth	amble	Crowd	Severe congestion

Therefore, different impedance coefficients can be selected according to different road conditions, and the product of the impedance coefficient and the actual distance can be obtained, and the road traffic condition can be expressed by the actual moving distance, as shown in formula (2).

$$d_m = R_{SD} * d_a \tag{2}$$

In formula (2), d_m represents the moving distance from the start point to the end point, and d_a represents the actual distance from the start point to the end point.

2.2 Objective Function

On the way to the destination of the EV, if the remaining capacity of the EV cannot reach the destination at one time, the EV is either on its way to a charging facility or charging. The CFSM method targets the total travel time of an EV and distributes the EV to different charging facilities for charging. If most of the EVs have the lowest total travel time, it indirectly indicates that the EV has a more reasonable choice of charging facilities. Because, if the EV is charging at will, most EVs will gather at the same charging facility to charge, resulting in long queues and traffic jams around the charging facility. However, in the lowest total time limit, EVs will re-select other reachable charging facilities to balance the overall utilization of the charging facilities.

$$T_{total} = T_{road} + T_{line} + T_{charge} \tag{3}$$

In formula (3), T_{total} represents the total travel time of the vehicle, T_{road} represents the travel time of the vehicle on the road, T_{line} represents the queue time of the vehicle at the charging facility, and T_{charge} represents the vehicle charging time. The constraint is as shown in formula (4).

$$T_{\min} = \min(T_{total}) \tag{4}$$

In formula (4), $T_{\min}$ represents the minimum time that the EV travels from the start point to the end point.

2.3 Total time description

The total time includes the travel time of the electric car, the queuing time, and the charging time. The travel time is the quotient of the actual travel distance and the average speed, as shown in formula (5).

$$T_{road} = \sum_{i=1; j=1}^{n} dis(i, j) / \overline{V} \tag{5}$$

In formula (5), the *dis* matrix represents the distance between the EV and the charging facility, and each row represents the

distance of an EV from each charging facility. The remaining electricity of the vehicle to the charging facility is as shown in formula (6).

$$E_r = E_s - d_m * Eav \tag{6}$$

In formula (6), E_r is the remaining amount of battery power that the vehicle reaches the charging facility, E_s is the battery power that the EV starts to drive., and Eav is the average energy consumption of the EV. The service time of the EV in the charging facility is the quotient of the required charging amount and the charging power, as shown in formula (7).

$$T_{charge} = (Ea - E_r) / P \tag{7}$$

In formula (7), Ea is the rated battery power of the vehicle, and P is the charging power of the charging facility. In a charging facility, the queued vehicles are set to $Car_{line} = \{C_1, C_2, \text{L}\ , C_n\}$, the service time of each vehicle is $T_{charge} = \{T_{charge\_1}, T_{charge\_2}, \text{L}\ , T_{charge\_n}\}$, and the service time is calculated by formula (7). The queue time of each vehicle is the sum of the service hours of all vehicles in front of the vehicle, as shown in formula (8).

$$T_{line\_n} = T_{charge\_1} + T_{charge\_2} + \text{L}\ + T_{charge\_n-1} \tag{8}$$

In formula (8), T_{line_n} represents the queuing time of the nth car.

2.4 Charging facility time utilization

In this paper, by defining the time utilization ratio of the equipment, the use time utilization ratio is used to measure the usage of each charging facility. This paper defines time utilization as the ratio of the service time of different charging facilities to the total service time of all charging facilities. When the time utilization deviation of each charging facility is not large, the overall utilization rate of the charging facility is more balanced, and the balance of the utilization rate of the charging facility is reflected by the variance of the time utilization rate. The time utilization rate of the charging facility is as shown in formula (9).

$$\eta_T = \frac{\sum_{i=1}^{n} T_{charge\_i}}{T_a} * 100\% \tag{9}$$

In formula (9), η_T is the time utilization of the charging facility, n is the number of vehicles served by the charging facility, and T_a is the total charging time of 100 EVs.

3. CFSM ALGORITHM

By considering the road traffic situation and calculating the feasible shortest path from the start point to the end of the vehicle based on the Baidu map, the path distance is recorded as *Db*.

$$Da = 0.9Ea / Eav \tag{10}$$

In formula (10), Da is the farthest distance that the EV can travel at the current battery power. To consider the effectiveness of the algorithm, 10% of the EV battery power does not participate in the calculation.

1. Start selecting conditions for charging facilities

(1) If *Da>Db*, there is no need to replenish the battery power and it is possible to reach the end point at one time.

(2) If *Da<Db*, it means that the current battery power cannot make the EV reach the end point at one time, and it is necessary to select the charging facility to replenish the battery power on the way.

2. In the case that the EV cannot reach the end point at one time, all the charging facilities in the acquisition area are *Ni*, and *i* is the charging facility number. The moving distance of the starting point S to each charging facility *Ni* is calculated in combination with formula (2) and is denoted as *Xi*. Select all charging facilities of *Xi<Da* and record it as the charging facility *Nj* that the current battery can reach. It is assumed that the EV reaches the rated battery power after charging at the charging facility.

3. Consider the utilization rate of the charging facility. Under the premise of considering the traffic situation, calculate the total travel time of each EV through the reachable charging facility, select the charging facility with the shortest total travel time, and if there is a charging facility with the same total time, select the charging facility closest to the end point.

4. Then, starting from the selected charging facility again, the end point is unchanged, and the charging facilities that have already visited are no longer involved in the calculation.

5. Repeat steps 1-4 until the reachable charging facility includes the end point and the nearest charging facility to the end point.

In the CFSM method, the input parameters/output data are shown in table 2.

Table 2. Input parameter/output data

data	parameter	Types
Input	Rated battery power	*Ea(kwh)*
	Battery power consumption	*Eav(kwh/h)*
	Start battery	*Es(kwh)*
	Charging facility	*Ci(i=1,2,…,10)*
	Charging power	*P(kw)*
	Impedance coefficient	R_{SD}
	start point	*S*

	End point	*D*
output	Number of service vehicles for each charging facility	*Vehicles-Num*
	Average total time of EVs	*Average-time*
	Charging facility time utilization	η_r

4. ALGORITHM SIMULATION

4.1 Simulation scenario

There are 100 electric cars in a certain area., based on the reference of domestic and foreign literature, the start battery power of 100 EVs are randomly distributed within the range x (kwh), $\{x \mid 40 \le x \le 80\}$. At the same time, according to the location distribution characteristics of the charging facilities [17]-[18], there are 10 charging facilities in the area.

4.2 Simulation results

Use MATLAB to simulate the motion scene of an EV. Among the three methods of NSCF, RSCF, and CFSM. The choice of charging facilities for 100 EVs is shown in Fig. 1.

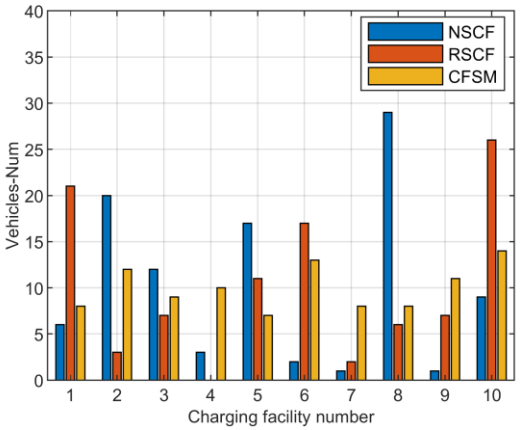

Fig. 1: Number of served vehicles for each charging facility

By observing Fig. 1, it can be found that when the NSCF and RSCF methods are used, there are zero-service and large-scale service charging facilities. For the CFSM method, the number of EVs served by all charging facilities is between [7, 14]. The number of service vehicles per charging facility is affected by the distance of the EV from the charging facility, the road traffic conditions of the driving, and the charging time, but there are no charging facilities for zero-service and large-scale services.

In the three methods of NSCF, RSCF, and CFSM, we processed the total time of 100 EVs obtained by the three methods, taking the total time of 10 EVs each time, calculating the average value and obtaining 10 sets of average values. Reflecting the total time rule of EVs in the three methods, as shown in Fig. 2.

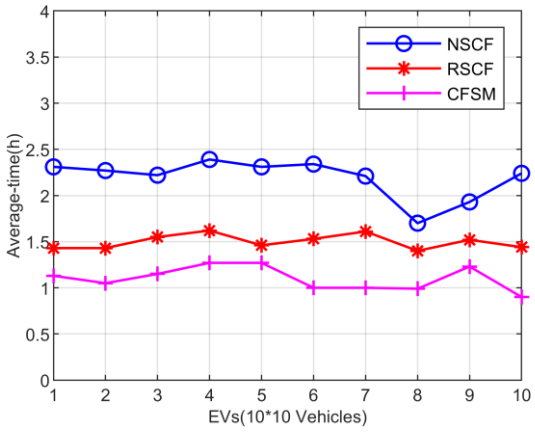

Fig. 2: Average total time of EVs

By observing Figure 2, it can be found that using the NSCF method, the average total time of the EV is relatively long because the queuing time increases when most of the vehicles are concentrated in one charging facility. Using the RSCF method, the average total time of the EV is between the NSCF method and the CFSM method. The reason is that when the charging facility is randomly selected, the owner can decide whether to leave the charging facility with a long queue time and select other reachable charging facilities. In the CFSM method, the average total time of the EV is lower than the NSCF method and the RSCF method. The time utilization of the charging facilities under the three methods is shown in Table 3.

Table 3. Time utilization of charging facilities

Charging facility	NSCF Time utilization	RSCF Time utilization	CFSM Time utilization
1	0.065	0.191	0.088
2	0.197	0.032	0.113
3	0.130	0.071	0.093
4	0.030	0	0.100
5	0.176	0.120	0.085
6	0.023	0.164	0.125
7	0.004	0.024	0.082
8	0.274	0.060	0.076
9	0.010	0.068	0.105
10	0.091	0.270	0.133
variance	0.0076	0.0066	0.0003226

It can be found from Table 3 that in the NSCF method, the time utilization rate of the charging facility 8 is the highest, the time utilization rate is distributed between 0.4% and 27.4%, and the variance between time utilization rates is 0.0076. In the RSCF method, the charging facility 10 has the highest time utilization, the time utilization is distributed between 0 and 27%, and the variance between time utilization is 0.0066. In the CFSM method, the time utilization rate of the charging facility 10 is the highest, the time utilization rate is distributed between 7.6% and 13.3%, and the variance between time utilization rates is 0.0003226. In terms of balance, the time utilization variance of CFSM is reduced by 95.8% and 95.1% compared with NSCF and RSCF. The above results show that when using the CFSM method, the

method can balance the utilization rate of the charging facility with respect to the NSCF method and the RSCF method.

5. CONCLUSION

At present, the construction of charging facilities is slow and unevenly distributed. When EV owners choose charging facilities to charge, they have great randomness, and the unordered charging of a large number of EVs will lead to an unbalanced utilization rate of charging facilities. Charging facilities with high load will increase their maintenance costs, while charging facilities with low load will be idle, resulting in unprofitability and loss. To solve this problem, based on the road traffic situation and the basic information of EVs, this paper proposes a method of equalizing the utilization rate of charging facilities (CFSM) under the constraint of the shortest total time. Compared with the nearest charging facility method (NSCF) and the random charging facility method (RSCF), the experimental results show that the CFSM method can balance the charging facility utilization rate.

6. ACKNOWLEDGMENTS

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Evaluating the Topaz ERP System Effectiveness Using a System Integrative Approach

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Abstract: ERP systems selection, adoption and implementation are a complex, lengthy and costly process which tends to face serious failure. Higher Education Institutions are rapidly adopting and implementing these systems despite some implementation failures that have been reported elsewhere. Thus, it is essential to perform post-implementation assessment of these systems to evaluate how much they have succeeded or failed in achieving their predetermined objectives. The purpose of this paper is to evaluate the effectiveness of topaz ERP systems in higher education institutions using a system integrative approach. Using a mixed-method research, data for quantitative and qualitative were collected and analyzed using partial least square – structural equation modeling (PLS-SEM) and inductive thematic analysis. The findings of the study revealed that financial perspective, customer/stakeholder perspective, and system quality perspective have significant influence or positive association with the effectiveness of topaz ERP systems evaluation in the Ghanaian higher education. The findings again, revealed that internal business process and learning and growth perspectives have no significant influence with the effectiveness of topaz ERP systems in Ghanaian context. Studies about the evaluation of ERP systems effectiveness in the Ghanaian higher education are rare. Available studies in Ghana have focused on the implementation issues and use only.

Keywords: ERP systems, Evaluation, ERP effectiveness, Balanced Scorecard, ISO 25010 Model

1. INTRODUCTION

The information system (IS) field over the years has seen a tremendous growth both in practice and research. The growth of information systems (IS) has played an essential role in improving the operations of business organizations and institutions. In this respect, ERP (Enterprise Resource Planning) systems come as integrated information systems, in order to plan, control and direct the business functions of an organization. Many studies have shown that ERP systems are effective in improving the operations of business organizations [3][19][27] while others have suggested otherwise [1][2][26]. Many different types of ERP systems such as SAP, Oracle, Baans and Microsoft have all been researched and evaluated for their effectiveness in organizations. The topaz ERP system which has also gained some popularity among higher education institutions (HEIs) is yet to be researched and evaluated. There is no literature that has reported about the effectiveness of topaz ERP system in HEIs. The high cost of implementing these systems needs to be evaluated in order to ascertain their effectiveness. Hence, (due to the popularity of the topaz system) there is the need to evaluate the effectiveness of the topaz system in order to justify its continuous use in the higher education institutions.

2. TOPAZ ERP SYSTEMS

Topaz as an ERP systems vendor has been delivering Microsoft Dynamics NAV and its successor Dynamics 365 Business Central (BC) to New Zealand organizations for over twenty years. Topaz ERP systems vendors have consistently delivered high quality, reliable and cost-effective solutions, on time and on budget. Other products that are delivered by topaz include topaz GEMS, Jet Global, Continia, Dynamics eshop, BI360, Scapta and Sana [35].

2.1 Microsoft Dynamics 365 Business Central (BC)

Business Central is the most popular ERP system in the world with over 2 million users worldwide. It offers powerful ERP Technologies to a broad industry base, and is flexible enough to be customized to any business and its unique requirements. It is an all-in-one business management solution that is easy to use and adapt, helping you connect your business and make smarter decisions. This all-in-one ERP business management solution helps organizations and institutions to connect their financials, sales, services, and operations together in order to streamline business processes, improve customer interactions, and make better decisions. Some features of Microsoft Dynamics 365 Business Central (BC) include:

- **Manage your Financials:** Make informed decisions, Accelerate financial close and reporting, Improve forecast accuracy.
- **Automate your Supply Chain:** Optimize stock levels, Avoid lost sales and reduce shortages, Maximize profitability.
- **Sell Smarter:** Deliver value at every touch point, Boost sales productivity, Deliver exceptional service.
- **Optimize Project Management:** Stay on budget, Plan with precision, Analyze project performance.
- **Delivering Operational Excellence:** Manage forecasting to fulfillment, Run your warehousing efficiently, Reach optimal output levels

2.2 Microsoft Power Platform

Microsoft Power Platform is an integrated application platform that combines Power BI, PowerApps, and Microsoft

Flow. This system improves productivity across business organizations and institutions.

2.3 Topaz Gems

These are bespoke solutions of topaz developed in-house and are designed to deliver additional functionality and efficiencies beyond the scope of the core technologies provided. The main features of these bespoke solutions include Advanced Allocations, Advanced Bank Reconciliation, Advanced Fixed Assets, Code Combination Validation, Electronic Funds Transfer (Direct Credits), Direct Debits, Purchase Line Approvals, Property Management, Contract Management, Job/Project Reporting Codes, Recurring Invoices, Landed Cost.

2.4 Microsoft Dynamics NAV

Some services provided by Microsoft Dynamics NAV include:

- License optimization
- Onsite/Off site training
- NAV performance optimization
- Custom development
- Hosting
- Problem Resolution

2.5 Continia

Continia delivers an end-to-end solution for document recognition, invoice approval and digital archiving documents. Automate every step of your daily invoice processing – from receiving and registering the documents to retrieving them again later for auditing and reporting. Some unique features of this system include Payment Management 365, Expense Management 365, Document Output 365, and MobilePay Invoice 365.

2.6 Sana

Sana integrates effortlessly with Business Central to deliver a first class e-commerce solution. Using Sana commerce can turn Dynamics 365 Business Central into the driver of your e-commerce experience, giving you the flexibility and web store features you need – without the added complexity of a long implementation process.

3. APPLICATION OF THE TOPAZ ERP SYSTEM

From institutional point of view, it is currently being used in the University of Cape Coast. The topaz ERP system is used at the administration section of the university, and it is one of the topaz Gems designed and developed in-house. Since the topaz ERP system (an accounting software system), has been adapted by the University of Cape Coast to manage its finance and human resource departments. At the finance department, topaz software system is used to manage the payroll, cash in-flows and cash out-flows, manage purchases and the store section of the university etc. In the human resource department, its being used to manage employees' records and information, salaries of employees and retirement packages etc.

The topaz system for the past three years of its use in the university has not seen any major setback. Even though as a system there may be some challenges, care has been taken to address those challenges when they arise. Nevertheless, evaluations must be done frequently to unearth challenges so that managements can find appropriate solutions to improve the system.

4. THEORETICAL BACKGROUND OF THE STUDY

The framework for this study is an adopted analytic framework of [28], which integrates both BSC framework and ISO 25010 Model to evaluate the effectiveness of ERP systems in HEIs. In their framework, five perspectives or constructs (representing independent variables) and one construct (representing dependent variable) were used to evaluate the effectiveness of ERP systems in HEIs. Twenty-six (26) indicators were also proposed in their framework to measure these five perspectives or constructs.

4.1 Balanced Scorecard (BSC) Framework

The Balanced Scorecard (BSC) framework, introduced by [22], is well-known as one of the most popular methods in performance evaluation. The cardinal purpose of BSC is to replace or overcome the inadequacies of the traditional financial-based performance measurement tools. The first and the original use of the BSC framework was performance measurement [22]. When BSC is used to measure performance, the focus is on the four performance metrics– financial, learning and growth, customer, and internal process metrics. By evaluating the four metrics, the BSC assists companies to track all the important aspects of a company's strategy as well as achieve continuous improvement of partnership and teamwork [8]. The BSC framework [21] presents the four perspectives and their measuring indicators. These four perspectives were defined by Kaplan in question forms as follows:

- Financial Perspective (How do the organization look to shareholders?)
- Customer Perspective (How do customers see the organization or the institution?)
- Internal Business Process (What must we excel at?)
- Innovation and Learning Perspective (Can we continue to improve and create value?)

4.2 ISO 25010 Model

The ISO 25010 is an international standard for software quality evaluation. It was originally presented in 1991 and has been revised and extended in 2007, 2011 and 2017. According to [20], the ISO 25010 quality model presents three aspects of software quality which address the internal quality, external quality and quality in use. Therefore, this model evaluates the quality of software in term of the external and internal software quality and their connection to quality attributes. In this respect, the model presents such quality attributes as a hierarchical structure of characteristics and sub-characteristics. The highest levels consist of eight (8) characteristics that are further divided into thirty- one (31) sub-characteristics on the lowest levels. The main significance of this model is that the model can be applied to the quality of any software product [12].

5. RESEACH FRAMEWORK AND HYPOTHESES DEVELOPMENT

Here, the six (6) adopted constructs identified in the proposed analytic framework of [28] will be discussed together with their measuring indicators. These six constructs or variables have been adopted to assess the effectiveness of ERP systems in HEIs.

5.1 Financial Perspective (FP)

This perspective according to [22] involves a question such as: To succeed financially, how should we appear to our shareholders? In the views of [31], the goal of ERP systems evaluation with respect to financial perspective is to reduce cost and improve return on investment (ROI). Various studies [6][9][27][31] have used financial perspective in the evaluation of ERP systems effectiveness.

This study has adapted the financial performance indicators of [8] for the evaluation of topaz ERP systems effectiveness in HEIs. In conclusion, financial perspective is a critical component for the evaluation of topaz ERP systems effectiveness in HEIs. We can therefore, agree that, the effectiveness of topaz ERP systems in HEIs can be affected (evaluated) by the financial perspective. We therefore, propose the following hypothesis:

H1: Financial perspective has a significant influence on topaz ERP system effectiveness in HEIs

5.2 Customer/Stakeholder Perspective (CP)

In [23], the researchers explained the customer/stakeholder perspective in a question form as: Are we delighting (or at least satisfying) our customers/stakeholders? Various studies [6][9][27][31] have used customer/stakeholder perspective in the evaluation of ERP systems effectiveness.

This study has adapted the customer/stakeholder performance indicators of [8] for the evaluation of topaz ERP systems effectiveness in HEIs. In conclusion, customer/stakeholder perspective is a critical component for the evaluation of topaz ERP systems effectiveness in HEIs. Hence, we agree that, the effectiveness of topaz ERP systems in HEIs can be affected (evaluated) by the customer/stakeholder perspective. We therefore, propose the following hypothesis:

H2: Customer/stakeholder perspective has a significant influence on topaz ERP system effectiveness in HEIs

5.3 Internal Business Process Perspective (IBPP)

This [23] explains the internal business process perspective also in a question form as: Are we doing the right things? And doing things right? Various studies [6][9][27][31] have used internal business process perspective in the evaluation of ERP systems effectiveness.

This study has adapted the internal business process performance indicators of [8] for the evaluation of topaz ERP systems effectiveness in HEIs. In conclusion, internal business process perspective is a critical component for the evaluation of topaz ERP systems effectiveness in HEIs. Hence, we agree that, the effectiveness of topaz ERP systems in HEIs can be affected (evaluated) by the internal business process perspective. We therefore, propose the following hypothesis:

H3: Internal business process perspective has a significant influence on topaz ERP system effectiveness in HEIs

5.4 Learning and Growth Perspective (LGP)

This perspective according to [22] involves a question: To achieve our mission and vision, how should we sustain our ability to change and improve? Similarly, [23] explains the learning and growth perspective also in a question form as: Are we prepared for the future? Various studies [6][9][27][31] have used learning and growth perspective in the evaluation of ERP systems effectiveness.

This study has adapted the learning and growth performance indicators of [8] for the evaluation of topaz ERP systems effectiveness in HEIs. In conclusion, learning and growth perspective is a critical component for the evaluation of topaz ERP systems effectiveness in HEIs. Hence, we agree that, the effectiveness of topaz ERP systems in HEIs can be affected (evaluated) by the learning and growth perspective. We therefore, propose the following hypothesis:

H4: Learning and growth perspective has a significant influence on topaz ERP system effectiveness in HEIs

5.5 System Quality Perspective (SQP)

According to [11], system quality measures the information system itself. This perspective considers the quality characteristics of the system or the software. In [18], the researchers defined system quality as performance characteristics of the ERP system with regard to ease of use, accuracy, reliability, efficiency and so forth. ISO 25010 Model has been proposed to evaluate the system quality of every system (ERP systems). Various studies [4][37] have used system quality perspective in the evaluation of ERP systems.

This study has adapted the system quality measuring indicators of ISO 25010 model for the evaluation of topaz ERP systems effectiveness in HEIs. In conclusion, system quality perspective is a critical component for the evaluation of topaz ERP systems effectiveness in HEIs. Hence, we agree that, the effectiveness of topaz ERP systems in HEIs can be affected (evaluated) by the system quality perspective. We therefore, propose the following hypothesis:

H5: System quality perspective has a significant influence on topaz ERP system effectiveness in HEIs

5.6 Effectiveness of ERP Systems (EOES)

Effectiveness of ERP system as a construct in this study is very significant; in the sense that it is one of the construct that this research study will seek to determine its relationship with other constructs. Effectiveness of ERP system in information system concept is about goal achievement and resource utilization. The effectiveness of an IS can be defined as the extent to which an information system actually contributes to achieving organizational goals [19] [34].

This study has adapted the effectiveness of ERP systems measuring indicators of [27] for the evaluation of topaz ERP systems effectiveness in HEIs.

5.7 Research Framework

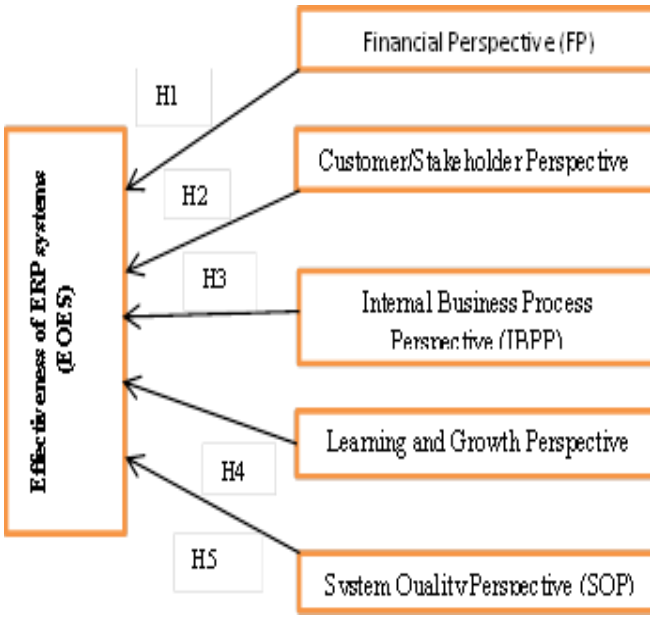

Figure 1: Proposed Analytic Framework, Source: Peters and Aggrey (2019)

6. RESEARCH METHODOLOGY

Since the research format is causal or explanatory research which normally test cause and effect relationship between constructs, the philosophical underpinning this study is realist assumption. Realists researchers normally test for both the qualitative and quantitative data, which they generate from a population sample and later, generate inferences from their results. The next section discusses the instrument development and data collection for this study.

6.1 Instrument Development

The instrument used for data collection contained scales to measure the various perspectives of the research model or framework. The research model included six constructs or variables, each of which is measured with multiple items. The questionnaire asked the respondents to rate the impact of factors (perspectives) on ERP effectiveness using 5 point likert scale with items ranged from 1 (strongly disagree) to 5 (strongly agree). Five (5) structured interview questions about the constructs were also designed to be answered by the respondents. In order to improve content validity of the instrument, these items were adapted from the literature review and experts judgment [33].

The items were reworded to reflect the context of ERP systems in higher educational sector. Also, to ensure face validity, some ERP professionals from both industry and academia were consulted; resulting in the review, reshaping and improvement in the questionnaires to the required standard.

6.2 Measurement Instrument

Measurement instrument used for the current research study composes six constructs and each of which is measured with multiple items (measuring indicators). Table 1 shows the constructs, their measuring items and their sources.

Table 1: Constructs, measuring items, and sources

Constructs	No. of Measuring items/indicators	Sources
Financial Perspective (FP)	5	Brown (2012)
Customer/Stakeholder Perspective (CP)	5	Brown (2012)
Internal Business Process Perspective (IBPP)	5	Brown (2012)
Learning and Growth Perspective (LGP)	5	Brown (2012)
System Quality Perspective (SQP)	6	ISO 25010 Model (2011)
Effectiveness of ERP Systems (EOES)	4	Parsa and Duffchahi (2015)

Source: Originated by the researcher

6.3 Case Study University

This study has adopted a case study approach to investigate the evaluation of topaz ERP systems effectiveness in HEIs. ERP systems evaluation is a phenomenon which is uncommon in higher education institutions. Despite the increasing adoption of ERP systems in HEIs, their evaluations have not well been understood. Research about ERP systems evaluations in HEIs has also been scanty. Therefore, to understand the details of ERP systems evaluations in HEIs, more case study researches are needed. This study selected University of Cape Coast (UCC) as its case study in the higher education based on the following reasons:

- Long term experiences with the use and management of topaz ERP systems, which will make the experts (respondents) to provide an objective evaluation of the system.
- To provide the researchers with rich data and information for the analysis of results.

6.4 Sample and Data Collection

Since ERP systems evaluations are complex and technical in nature, they need experts or people who are familiar with these systems to do data gathering. In this research study, administrators and managers of the case study university constitute the respondents. These two groups of respondents were selected because of their daily use and interactions with the ERP systems at the university. A concurrent mixed-method sampling which comprises probability or random technique and purposive technique was used to select the respondents from the case study university. The technique helped to generate single sample for both quantitative and qualitative analysis. A total of 80 questionnaires were sent to

the case study university (University of Cape Coast). Of the valid responses, 71 percent were males while 29 percent were females. Table 2 shows the detailed sample demographics of our respondents.

Table 2: Demographic information of the sample

University of Cape Coast				
Case	Correspondent	Department or Unit	System	Gender
Case Study: University of Cape Coast	1 – 30 (30)	Finance	Topaz System	Male: 71%
	31 – 40 (10)	Human Resource		
	41 – 47 (7)	Stores		
	48 – 55 (8)	Payroll		Female: 29%

Source: Originated by the researcher

7. QUANTITATIVE DATA ANALYSIS OF THE CASE STUDY

Data collected were analyzed using the partial least square approach to structural equation modelling (PLS-SEM) on SmartPLS 3 [29]. Structural equation modelling is a powerful multivariate data analysis tool that estimates or assesses a complete model or framework through a two-step approach [10] [24]. According to the authors, structural equation models can first be examined by assessing its measurement model for reliability and validity. After the assessment of the measurement model, then followed the structural model evaluation which tests the structural paths between the latent variables in the proposed model or framework. This two-step approach to structural equation modelling is what has been used in this study to validate our research model or framework. The current study employs PLS-SEM because preliminary analysis exhibited that the data were non-normal. SmartPLS 3 is however able to handle extremely non-normal data [16]. It also performs bootstrapping analysis to help assess the statistical significance of the loadings and of the path coefficients [30]. Also the parameters of PLS approach were estimated using a resampling approach (i.e. bootstrap or jackknife) since it lacks the classical parametric inferential statistics [36].

7.1 Case Study: University of Cape Coast

Measurement model

Measurement model in PLS-SEM can be assessed by three important psychometric properties. These are reliability of constructs, convergent validity and discriminant validity. Reliability of constructs in this study was assessed using cronbach's alpha and composite reliability measures to test for the internal consistency of the model. As displayed in table 3, each construct's cronbach's alpha and composite reliability values exceeded the acceptable level of 0.7 recommended by [25]. It can therefore, be concluded that the measurement model shows good reliability. Convergent validity of the model was also assessed based on two standards, recommended by [5]: (a) Average Variance Extracted (AVE) for each construct should exceed 0.5 [13] and (b) Indicator Factor Loadings should exceed 0.5 [15]. Table 3 once again shows evidence of convergent validity of the model. We therefore, conclude that the measurement model exhibits good convergent validity.

Discriminant validity on the other hand was assessed using the Fornell-Larcker criterion, which state that the AVE of each latent construct should be greater than the highest squared correlations between any other construct [13]. It is evident from table 4 that the square root of the AVEs for each construct is greater than the cross correlation with other constructs. Based on these results, the discriminant validity of the measurement model was established.

Table 3: Results of reliability and convergent validity

	CP	EOES	FP	IBPP	LGP	SQP	CA	CR	AVE
CP1	**0.925**	0.568	0.244	0.579	0.380	0.326	**0.899**	**0.928**	**0.725**
CP2	**0.733**	0.541	0.437	0.542	0.427	0.314			
CP3	**0.933**	0.555	0.179	0.618	0.401	0.332			
CP4	**0.662**	0.409	0.261	0.580	0.188	0.294			
CP5	**0.962**	0.596	0.232	0.647	0.390	0.368			
EOES1	0.358	**0.832**	0.411	0.517	0.122	0.900	**0.669**	**0.817**	**0.600**
EOES2	0.575	**0.693**	0.359	0.463	0.307	0.388			
EOES3	0.590	**0.793**	0.493	0.572	0.507	0.529			
FP1	0.184	0.395	**0.651**	0.428	-0.007	0.358	**0.744**	**0.842**	**0.577**
FP2	0.270	0.416	**0.783**	0.455	0.136	0.356			
FP3	0.166	0.297	**0.631**	0.197	0.051	0.186			
FP4	0.310	0.512	**0.934**	0.555	0.321	0.339			
IBPP1	0.680	0.539	0.501	**0.865**	0.659	0.302	**0.771**	**0.866**	**0.684**
IBPP2	0.499	0.409	0.426	**0.727**	0.251	0.206			
IBPP5	0.553	0.664	0.471	**0.881**	0.277	0.605			
LGP1	0.232	0.261	0.152	0.246	**0.686**	0.072	**0.812**	**0.869**	**0.574**
LGP2	0.395	0.299	0.190	0.459	**0.845**	0.109			
LGP3	0.269	0.345	0.196	0.301	**0.696**	0.233			
LGP4	0.343	0.184	-0.132	0.298	**0.640**	0.047			
LGP5	0.393	0.331	0.191	0.471	**0.890**	0.088			
SQP1	0.298	0.710	0.253	0.345	0.181	**0.879**	**0.956**	**0.965**	**0.822**
SQP2	0.422	0.828	0.431	0.499	0.139	**0.973**			
SQP3	0.342	0.702	0.350	0.470	0.045	**0.900**			
SQP4	0.346	0.729	0.409	0.431	0.205	**0.883**			
SQP5	0.248	0.649	0.418	0.361	0.135	**0.831**			
SQP6	0.417	0.801	0.396	0.495	0.144	**0.966**			

Table 4: Discriminant validity using Fornell-Larcker Criterion

	CP	EOES	FP	IBPP	LGP	SQP
CP	**0.852**					
EOES	0.633	**0.775**				
FP	0.315	0.544	**0.760**			
IBPP	0.696	0.667	0.561	**0.827**		
LGP	0.428	0.387	0.187	0.476	**0.758**	
SQP	0.385	0.815	0.415	0.481	0.156	**0.907**

Note: Square roots of AVE shown on diagonal and in **bold**, while off-diagonals are inter-construct correlations.

Structural model

In order to determine the significance of each estimated path, the bootstrapping or procedure was used with 5,000 resamples drawn with replacement. Here too, coefficient of determination R^2, Stone-Geisser Q^2 and standard root mean square residual (SRMR) were determined to assess the quality of the model or framework. The results for the structural model assessment are presented in table 5 and figure 2.

Financial perspective was found to have a direct significant influence on effectiveness of ERP systems with parameters ($\beta = 0.164$, $p = 0.046$), thereby providing support for H1. Again, customer/stakeholder perspective was found to have a significant influence on effectiveness of ERP systems with parameters ($\beta = 0.268$, $p = 0.005$), providing support for H2. Contrary to expectation, internal business process perspective was found not to have a significant influence on effectiveness of ERP systems ($\beta = 0.034$, $p = 0.731$), providing no support for H3. Learning and growth perspective was also found not to have a significant effect on effectiveness of ERP systems with parameters ($\beta = 0131$, $p = 0.064$), thereby providing no support for H4. System quality perspective was found to have the most significant influence on effectiveness of ERP systems ($\beta = 0.607$, $p = 0.000$), providing support for H5.

Finally, to assess the fitness of the model in PLS we used the Stone-Geisser Q^2 (predictive relevance) [14][32] and the standard root mean square residual (SRMR). Q^2 is a measure of how well the observed values are reproduced by the model and its estimated parameters. Q^2 value greater than 0 is an indicative of predictive relevance. The Q^2 value for effectiveness of ERP systems in this model is 0.424, indicating predictive relevance. The SRMR value for the model was also found to be 0.069, which is far below the 0.08 threshold recommended by [17]. Therefore, the model presents a good model fit.

Table 5: Path coefficients and their significance

Hypotheses	Path	Standard path coefficient	T Statistic	P Value	Result
H1	FP→EOES	0.164 *	1.994	0.046	Supported
H2	CP→EOES	0.268 **	2.800	0.005	Supported
H3	IBPP→EOES	0.034ns	0.344	0.731	Not Supported
H4	LGP→EOES	0.131ns	1.851	0.064	Not Supported
H5	SQP→EOES	0.607 ***	9.149	0.000	Supported
Coefficient of determination R^2					0.827
Stone-Geisser Q^2					0.424
SRMR					0.069

Note: ns = not significant; *p < 0.05; **p < 0.01; ***p < 0.001

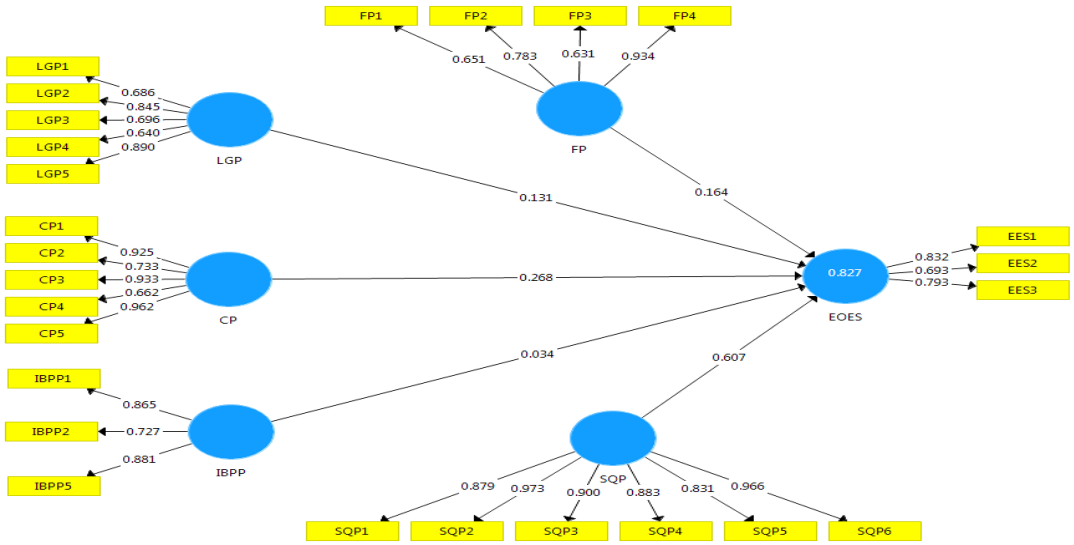

Figure 2: PLS results for structural model (University of Cape Coast)

8. QUALITATIVE DATA ANALYSIS OF THE CASE STUDY

Data collected by qualitative method (interviews) were analyzed using inductive thematic analysis. According to [7] thematic analysis is "a method for identifying, analyzing and reporting patterns within data". Inductive thematic analysis was chosen by the researchers to help derive meaning from the patterns of qualitative data set to enhance and validate results of the quantitative analysis.

8.1 Case Study: University of Cape Coast

Topaz software system is the ERP system used by the University of Cape Coast. Topaz ERP system integrates both the finance and human resource departments of the university and has been implemented for the past three years. The interview with administrators and managers focused on the following specific points or themes:

Financial perspective of topaz ERP systems effectiveness

One of the key benefits of implementing ERP systems at higher education is its ability to manage financial aspects or activities of that institution. According to the administrators, the university acquired the topaz ERP system to consolidate all their accounts preparations. They stated that the topaz system has helped to manage investment portfolios, management reporting and financial reporting:

Topaz system has really enabled the university to manage its investment portfolios, generate management and financial reports as and when needed by the management (Managers).

The administrator also interviewed asserted that topaz system has helped reduced cost of operations, managed students fees payments and detections of financial omissions such as overpayments and underpayments of certain goods and services:

Topaz system has helped us to reduce cost of operations, manage student's fees payments and detections of financial omissions such as overpayments and underpayments of certain goods and services (Administrators)

Customer/Stakeholder perspective of topaz ERP systems effectiveness

ERP systems come with great benefits to its stakeholders such as students, academic and non- academic staff, governments and affiliate institutions. According to the managers, topaz system has helped the university to prepare and deliver all its financial and human resource management reports to government for decision-making. The managers also pointed out that, even though the topaz system does not have a direct link to government system (controller and accountant general department system), it is still able to generate and deliver the information needed.

Even though the topaz system does not have a direct link to government system (controller and accountant general department system), it is still able to generate and deliver the information needed by government for decision-making (Managers)

The staffs of the university (academic and non-academic staff) do not have the direct use of the topaz system; they only receive their electronic payslips from the system through their email addresses (Administrators).

Internal business process perspective of topaz ERP systems effectiveness

Because the topaz system is not a web-based system, working remotely is a challenge since you cannot access the system anywhere to do your work. To work with the topaz system you must have a connection to the server hosting the software system or you must have the software system installed on your computer (Managers).

We sometimes experience network connection problems to the system, making it difficult to complete most of our job processes and activities. Again, we sometimes experience slow response to the topaz system (Administrators).

Learning and growth perspective of topaz ERP systems effectiveness

Training and development is important for every staff member of the university. For that matter, the managers stated that users of the topaz system need short training courses that will enable them to be effective in their job:

Initially, topaz system came with its documentations to help users to learn how to use the system; however, due to customizations to the system, these documentations have been rendered useless or redundant. Support to the system sometimes takes time to come, creating delays to most of the processes and activities of the university (Managers).

Vendor training was done for us initially after the system was implemented, but since that time no other training and development section has been organized for us. We need short training courses to develop our capabilities on the use of the system (Administrators).

System quality perspective of topaz ERP systems effectiveness

Most information systems are effective because their system qualities or features can be used to achieve their purpose or goals. The managers stated that topaz system came with several features that have really helped to achieve its effectiveness.

Topaz systems are more user-friendly, easy to learn and easy to navigate your way through. It is not a complex and difficult software system to learn and use. It comes with a simple graphical user interface (GUI) that can easily be used (Managers)

With topaz system our data and information are well secured from intruders. The system comes with strong security features that have prevented many people from getting into the system through backdoor. The only challenge to topaz system quality is the absent of web-interface module (Administrators).

9. DISCUSSIONS AND IMPLICATIONS

Studies that examine ERP systems effectiveness have all been done in the context of business organizations. By examining the determinants of topaz ERP systems effectiveness in the Ghanaian higher education, we add new insight into the existing literature by offering a better theoretical understanding of ERP systems effectiveness in general. Although the Ghanaian higher education is rapidly adopting and implementing ERP systems, very little is known about their effectiveness evaluations. In this regard, our study extends knowledge on ERP systems effectiveness evaluation in the context of Ghanaian higher education. The study examines the influences of financial perspective, customer/stakeholder perspective, internal business process perspective, learning and growth perspective and system quality perspective on topaz ERP systems effectiveness in Ghanaian higher education. A case study was conducted and five (5) relationships with the study's constructs were hypothesized and tested with PLS-SEM.

From the quantitative analysis, three (3) of the hypothesized paths were supported and two (2) were rejected. These results were in consistent with our qualitative analysis results and also with the work done by [27]. The implications of these results suggest that ERP systems effectiveness in the university is greatly influenced by financial, customer/stakeholder and system quality perspectives. For that matter, the university must continue doing its best to maintain and improve these perspectives of the system. Again, these results also imply that the university is not achieving effectiveness of ERP systems in the internal business processes; and learning and growth perspectives. This is in partial support of the work done by [27], who stated that internal business process perspective has the greatest impact while learning and growth perspective has the least impact. In summary, the ERP system (topaz system) of the university has been successfully evaluated and has proved effective with our research model.

10. LIMITATION AND FUTURE RESEARCH DIRECTIONS

Despite the study's interesting findings and implications, it is not without limitations. These limitations, however, present directions and opportunities for future research. First, this research included only five specific factors based on prior research works. There may be additional factors which determine or influence ERP system effectiveness in HEIs that were not examined in this study. Secondly, there are other evaluation models or frameworks that can be integrated to study ERP systems effectiveness in HEIs. Thirdly, cross-sectional and longitudinal surveys can also be used to study the effects of these constructs on ERP systems effectiveness in HEIs. Lastly, we suggest researchers investigate ERP

systems effectiveness in HEIs by comparing results from developed nation to developing nation.

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APPENDIX

Financial Perspective (FP) and Indicators: Adapted from Kaplan (2010) and Brown (2012)

1. The topaz ERP system has helped us to reduce cost of operations
2. The topaz ERP system has helped to facilitate enrollment growth of the university
3. The topaz system has assisted us to manage our investments and assets
4. The topaz system has brought tremendous efficiency in our financial and management reporting
5. Donations from alumnus and donor partners have been facilitated by the topaz system

Customer/Stakeholder Perspective (CP) and Indicators: Adapted from Kaplan (2010) and Brown (2012)

1. The topaz system has assisted students to register courses online, check their results and assess their lecturers
2. The topaz ERP system has helped students to graduate on time without any backload of students
3. The topaz system has helped to optimize learning experiences among students
4. Relationships with the government and affiliate institutions have been improved with the topaz ERP
5. Topaz ERP system has enabled staff members to check their payroll information, apply for leave, apply for promotions and retirement issues

Internal Business Process Perspective (IBPP) and Indicators: Adapted from Kaplan (2010) and Brown (2012)

1. The topaz system has assisted us to create new innovative programs and activities
2. The topaz system has improved processes and activities leading to the delivery of information
3. Students support network has been strengthened with the topaz ERP systems
4. With the topaz ERP system, multiple tasks can be handled and to generate different formats of report
5. Topaz ERP systems help in the internal communications among various units or departments

Learning and Growth Perspective (LGP) and Indicators: Adapted from Kaplan (2010) and Brown (2012)

1. With the topaz ERP system use in the university, various qualified faculty and staff members have been retained
2. The topaz system supports faculty professional practice and research
3. The topaz system comes with easy documentations and supports
4. The topaz system has helped me to learn excel, access and other software applications to develop my skills
5. Topaz ERP system has assisted to improve and manage information technology (IT) infrastructure

System Quality Perspective (SQP) and Indicators: Adapted from Kaplan (2010) and Brown (2012)

1. The topaz ERP system provides security to our data and information
2. in the event of any disaster, data and information can easily be recovered
3. It is easy to learn and use the topaz ERP system
4. Time and effort are not wasted in the topaz system
5. Changes or modifications can be made in the topaz system without affecting or introducing defects into the system
6. The topaz system can easily be moved to different hardware platforms or environments for other operations

Effectiveness of ERP System (EOES) and Indicators: Adapted from Parsa and Duffchahi (2015)

1. Topaz ERP system makes information available to its users
2. Topaz ERP system helps to integrate processes within the organization or the institution
3. The topaz system prevents parallel or similar operations of activities within the organization or the institution
4. Topaz ERP system prevents entering of duplicate records of data and information

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The Efficacy of Integrating Various Technological Systems into the Management of Smart TV Station DataCentres

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Abstract: When one thinks of computing, they almost immediately radiate towards the billions upon billions of information that is floating through the air via waves, as it passes through one medium to the next. It is also conceivable that the transfer of this information is often times without hindrance, however, with the proliferation of information within this digital age, it is almost common place to hear of servers or storage sites having crushed. Enter the datacentre. The datacentre is the main storage centre in which servers for information storing are housed. Over the last decade, datacentres have ballooned to become the core of the technological landscape. The biggest of them to date have massive numbers of servers running across a plethora of machines while running various distributary channels of applications. With applications being written in cognizance of locality of the datacentre, the unavoidable channelling to the many different machines, due to the enormous computations distributed to them, may lead to the slowness of the network and such distribution of information. This is indication that as the datacentres continue to increase in size and capacity, the difficulty in managing them also increases. This has thus put or has the potential to put the information and functionality grid under threat of imploding with disastrous consequences. Thus solutions that will parallel this expansion in the size of data distribution as well as the datacentre storage sizes, are needed.

Keywords: SmartTV datacentres, datacentre management, efficiency, Cloud Computing, Internet of Things, VoIP, AI, Automated Systems

1. INTRODUCTION

This research therefore is undertaken to recommend the efficacy of the use of some of the current technological advancements that exist in better managing the flow of data from the datacentre to the intended recipients of such information on their various devices. Specifically, the research seeks to focus on the advent and growth of the smart TV phenomenon, especially as technology has grown in the last decade and changed the way we view TV. However, behind the scenes lies the issue of the enormous datacentres that this growth has created and the 'nightmare' of the manageability of them. Of discussion in this research will the integration of the VoIP tool in the seamless flow of information from the datacentres to the devices as impending destinations. This VoIP tool cannot, however, just be infused into network administration in abstract. The research will further focus on how elements such as Cloud computing as a virtual storage, Artificial Intelligence (AI), the Internet of Things (IoT) and Automation of the system, can be utilised in enabling the integration of VoIP in managing and administering the ever fast paced increase of datacentres.

It is hoped, and thus is the intention of the author that this research provides for further discourse to the academic technological sector as well as the practical technological policy sphere regards the management, functionality as well as the applicability of methods that can be recommended to bolster the efficiency of smart TV station datacentres. It is here I consider the literature in brief.

2. LITERATURE REVIEW

In the early 2000's, a shift in technological advancements began to be witnessed within the TV and broadcasting industries around the world. This shift was when TV transferred from the analogous system of broadcasting to the more elaborate digital broadcasting (Watanabe et al, 2003). This paved the way for the advent of smart TV's as we know them today (Lee & Kim, 2013). Lee & Kim (2013)

further note that in the 2012 period alone, over 80 million Smart TV's were sold worldwide with projections of an even bigger and wider number and reach in the future. The authors further note that Smart TV's are no longer viewed as just devices for the screening of news and just other TV programming, but transcend the broader scale of other facets of day–to-day application such as entrepreneurship, learning and for working purposes.

Further, the enormous potential for integration into other IT advancements cannot be downplayed (Lee & Kim, 2013). This transition and growth has inevitably led to more information being transmitted (Villars et al, 2011) with the further inevitability of the increase in data storage facilities. In 2010 over 1 zettabytes (ZB) of data was created with a 2014 projection of 7ZB (7 trillion gigabytes) being made (Villars et al, 2011), indicating a staggering rate of data production as has not been witnessed before. The proliferation of this data has created a demand for enormous central storage spaces for its proper management and distribution. Contextually, in 2007 research indicates that 6.1 exabytes (EB) of storage space were installed globally with the figure in 2010 increasing to 16.4EBs and an even bigger 79.8EBs of storage space by 2014 (Villars et al, 2011).

The challenges in the past for most organizations had been the enablement of speedier and more transactions. Current challenges include the quicker and large distribution of this information especially from cloud based systems to the devices through which it is accessed by users. Future challenges may encompass the eco-sustainability and more efficient methods of utilising all this information (Villars et al, 2011). This is the quagmire faced by most IT system managers, Smart TV stations included. What then are the information technological tools that may aid in better managing datacentres such as a Smart TV station?

3. INFORMATION TECHNOLOGICAL PLATFORMS

3.1 Cloud Computing

With such statistics ranging from 1.15 billion Facebook users (and more than 60 000 servers), just under 2 billion videos viewed daily on YouTube and inquiries processed on Google in the range of 1.2 billion (with more than 1 million servers and plans of increasing this number to more than 10 million), it is incomprehensible how such gargantuan data can be stored and still be managed and distributed at the rate at which it is currently (Lin, 2008). Just the processing alone would require more than one device. The storing of all this in formation necessitates the investing in building large scale datacentres which consume large amounts of energy, generally cost more (such as Microsoft's 499 million US dollar investment at one point), produce quite a lot of heat and may require expertise and regular maintenance (Lin, 2008).

One way of alleviating most of these challenges was the introduction of Cloud Computing. The cloud has been described as;

> *Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Lin, 2008. p - 35).*

Identifiable cloud elements are then the self-service at your convenience ability, accessing a broad network of information, the ability to pool various resources together amongst other characteristics (Lin, 2008). The cloud makes provision for entire applications and other necessities such as hardware as well. Ranging from Public type clouds to the Private (entity based) clouds, these may run multiple tasks for the end users such as hosting applications,

the storage and back-up of data, delivering content, e-commerce, the hosting of the media and indeed Smart TV station applicability.

The main benefits of cloud computing is that more services can be leveraged for the end user by the providers with much less hardware to achieve this thus pointing towards a cost saving measure. These may include the provision of virtual machines with different capacities and capabilities as well as migration and over committal of these resources to no detriment of the user (Velte et al, 2010), specific configuration to that particular user thus keeping the information isolated (Lin, 2008)

Issues of concern would may be the unpredictability of performance, especially in instances of outages, transferability to other cloud storage if need be, issues surrounding the security of the data, the scalability of the cloud particularly the storage and boot time (Velte et al, 2010). Next I consider the Internet of Things.

3.2 The Internet of Things

The Internet of Things (IoT) basically refers to the number of technological devices that currently exist and whose functionality is based, connected or dependant on the global internet (Taazaa, 2019). A number of technological trends have made IoT possible in recent developments. Firstly, embedded platforms have become much more powerful with microcontrollers basically being pushed out by the more multi-tasked enabled CPU's. This is because microcontrollers can no longer meet the requirements needed for the upkeep and run rate that CPU's can provide such as operating system (OS) hosting, compatibility with popular tech system protocols to mention a few (Taazaa, 2019).

Secondly, a massive wave of software ecosystems with developers in tour of developing OS's and protocols, have basically pushed off mainstream OS's such as QNX and VxWorks while challenging the bigger brands such as Windows and Linux. This was mainly due to the fall out to the popularity of hardware requirements that the big players offered while newer protocols with limitations only specific towards these new players were being written (Taazaa, 2019). Thirdly, the development of wireless communication has witnessed an increase in the accessibility of the internet and information through it even for the lower powered devices without a noticeable cost increase on that device. The WiFi has even become faster. All these trends are then gelled together by a fourth element of cloud computing (basically as already discussed above) (Taazaa, 2019).

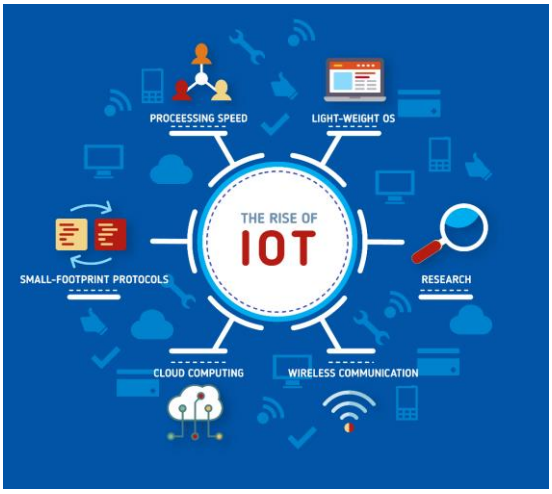

Figure 1: A basic representation of IoT trends (source; Taazaa, 2019)

3.3 Artificial Intelligence (AI)

Artificial Intelligence (AI) can at best be described as the simulated human intelligence that is embedded in machines such as computers and in how they process information (TechTarget, 2019). Such processing will mainly require the acquisition of data, the machine then using the set rules to evaluate such data or information to achieve desired results of application and then finally the ability of the machine to self-correct itself in the event of misdiagnosed information (TechTarget, 2019). In our present case

machine vision application would be the suited fit for AI application.

With rapid recent developments especially in the demand for multi-media content, the processing of algorithms associated with programmes running these has created a large consumption of computing and storage (Lu et al, 2015). The solutions have been the drive towards cloud computing and associated tech tools that will make the management and necessity of large datacentres both much more efficient and less costly for IT managers globally. The basic solution may lie in creating a hybrid cloud storage and management system which will integrate both private and public datacentres (DC's) (Lu et al, 2015).

The basic process will involve the renting of resources from public DC's with the creation of virtual machines (VM's) for use and distribution to end users and the possibility of replicating this process across multiple geo-locations for the ease and cost effectiveness of using these resources (Lu et al, 2015). The further yardstick of creating a monitoring and corrective programme that will monitor and manage private servers as well as the VM's under the public DC's especially for latency issues that may be experienced. This process will include the writing of specific algorithms that will monitor the dynamic requests made by users at the same time monitoring the cloud in deriving better scaling for the information under that cloud storage (Lu et al, 2015). This is the AI arm of the system.

3.4 Automated Systems

From the perspective of datacentre management as well as cloud computing spaces, can be noted the existence of various service providers to service the various clientele with different services and policies price-wise. This understandably creates challenges for system administrators in being able to create value provisions for the clients and interlinking the different service providers into one seamless service (Son, 2013). Further, allocating resources from the same service providers, should such be preferred is not a guarantee as the fundamentals of cloud computing are such that they are flexible in managing such resources. Datacentres may exceed their capacity and thus the provision of any further resources becomes curtailed as new VM's may also not be formulated (Son, 2013).

In order to avoid this typical system crush, an automated programme may be designed that will employ the advancements of AI integrated into the DC online system which will enable the for the selection of the most suitable service providers for clients of that service, and on gazetted commands, will manage these resources from such service providers and further create new VM's from then when the system picks a need for it (Son, 2013).

3.5 The VoIP System

The Voice over Internet Protocol (VoIP) system is best described as a virtual telephone line. With the advent of the VoIP tech system, it has enabled the transmission of various conversations wirelessly over the internet (Fayyaz et al, 2016). With its rapid growth as a preferred form of internet communication, VoIP has had significant influences on the way communication is headed into the future. Its popularity over conventional methods of communication make it an assist to be integrated into such management policy decisions as the SmartTV station management. Low costs are the main pull factor for the popularity of the VoIP technology (Fayyaz et al, 2016). A plethora of other uses for the VoIP system such as the transmission of data or media of various sizes is a further motivator for the integration of the system.

Of interest is the Quad-play technology which basically allows for the transmission of video services, voice, data and surveillance services over the internet through utilising VoIP and allowing this content to be channelled through a single network (Fayyaz, 2016). Having

originally been designed to transmit just voice communication, the technology has evolved to such heights that main stream businesses as well as small scale one, now depend on the VoIP system for their main communication needs (Fayyaz, 2016). Writing algorithms into the datacentre system with a set-up of commands and a system that will recognise commands as imputed to it either verbally or through the introduction of certain pictures or media content, must be the end goal for the efficient management of the datacentre under the SmartTV station.

4. CONCLUSION

What we have explored so far in brief schematic form are the possibilities of turning one of the most energy consuming products today which is the datacentre, into one of the most sustainable and eco-friendly technological products while transmitting for us the much needed information. The possibility of reducing the SmartTV station's datacentres may be high with the integration of systems expounded above, either as singular or multiple form. This will enhance the capabilities of the managers of such entities and thus providing better content at much better clarity and speeds. Because the technology already exits, it will be upon the completion of this and other various research works on the matter that will basically assist in policy considerations as the efficacy on the reliance of these and other technological systems comes into question.

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