ENHANCEMENT OF DATA CENTRE POWER CONSUMPTION THROUGH A PREDICTIVE ALGORITHM

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D) IN ELECTRICAL AND ELECTRONICS ENGINEERING IN THE DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

OCTOBER 2022

ACCEPTANCE

This is to attest that this thesis is accepted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Electrical and Electronics Engineering in the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Nigeria.

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DECLARATION

I, AFOLABI, ROTIMI (15PCK01078) declare that this research was carried out by me under the supervision of Prof. Bamidele Adebisi of Department of Engineering, Manchester Metropolitan University, Manchester, United Kingdom and Prof. Anthony U. Adoghe of the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that the thesis has not been presented either wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this thesis are duly acknowledged.

AFOLABI, ROTIMI

Signature and Date

CERTIFICATION

We certify that this thesis titled "**ENHANCEMENT OF DATA CENTRE POWER CONSUMPTION THROUGH A PREDICTIVE ALGORITHM**" is an original research work carried out by **AFOLABI, ROTIMI (15PCK01078)** in the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria under the supervision of Prof. Bamidele Adebisi and Prof. Anthony U. Adoghe. We have examined and found this work acceptable as part of the requirements for the award of Doctor of Philosophy (Ph.D) degree in Electrical and Electronics Engineering.

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DEDICATION

This project work is dedicated to Almighty God, The Most Gracious and The Most Merciful for making this project work a reality through the provisions and sustenance which He provided.

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LIST OF ABBREVIATIONS

Abbreviations	Description
ASUS	Adaptive Server Utilization Scheme
ARMA	Autoregressive Moving Average
CC	Cloud Computing
CPU	Centre Processing Unit
DC	Data Centre
DPM	Dynamic Power Management
EC	Energy Consumption
GA	Genetic Algorithm
I.T	Information Technology
ICT	Information Communication Technology
IoT	Internet of Things
KF	Kalman Filter
LPCPM	Linear Power Consumption Prediction Model
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
NCC	Nigerian Communication Commission
PUE	Power Usage Effectiveness
PCoKFGA	Power Consumption Optimization using KF with GA
RMSE	Root Mean Square Error

ABSTRACT

Data Centres (DCs) are of paramount importance in the telecommunications industry to meet up with the rapid increase in the demand for telecommunication services. However, the cost of power consumption of a DC accounts for about 80% of the cost incurred in maintaining Data Centres. This situation is further exacerbated in a country like Nigeria where there is highly unstable power supply from the national grid. The unstable power supply leading to increase in the cost of maintaining a DC due to alternative sources of power supply required. Several research projects such as power consumption prediction model and energy consumption optimization have been carried out to reduce the power consumption of Data Centres. However, the existing works suffer from assumption that all the modular that are not carrying traffic will be on idle mode. This generates additional heat and requires a cooling system that consumes extra power compared to when it is completely off. Also, some of the techniques proposed in the literature lack an accurate prediction of the power consumption in Data Centres. This research therefore reduced DC power consumption through a predictive algorithm using Genetic Algorithm (GA) with Kalman Filter (KF) parameters. Data were collected from five different servers in Nigeria, named BSC 13, BSC 14, BSC 15, RNC 05 and RNC 06 using power analyser, clamp meter and thermometer. The historical assessment of data collected were carried out for the DC under study. Two years data (January to December of 2019 and 2020) were collected from the five servers. The data were recorded on an hourly basis for each 357 days in 2019 and 358 in 2020, to obtain a total of 8568 and 8592 samples respectively. All the hourly data measured, and the ones displayed by rectifier Human Machine Interface (HMI) were compared to obtain the percentage error and ascertain the integrity of the data. The data were pre-processed for consistency and the final data used for each year under study, consists of 8400 samples. The final data were divided and categorized into two Datasets. The first dataset was used to create a prediction model, while the second dataset was used for testing. The GA was used to obtain best KF parameters, afterwards KF was used to predict the future power consumption on hourly basis for each day of the week. The proposed model gave low power consumption with accurate prediction when compared with the existing models. Linear Power Consumption Prediction Model (LPCPM) and Adaptive Server Utilization Scheme (ASUS) were also utilized with the assumption that the idle servers are not energised when not required, the performances of these models using different metrics when compared to the existing models in literature demonstrates superiority in terms of cost, power consumption reduction and negligible prediction average absolute error of 0.0025 (0.25%) was obtained.

Keywords: Data Centre, Genetic Algorithm, Kalman Filter, Base Station Controller, Radio Network Controller, Linear Power Consumption Prediction Model, Adaptive Server Utilization Scheme, Power Consumption and Samples.