Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

QoS-aware Virtual Machine (VM) for Optimal Resource Utilization and Energy Conservation

B. Vivekanandam
Senior Lecturer, Faculty of Computer Science and Multimedia, Lincoln University College, Malaysia.
E-mail: vivekanandam@lincoln.edu.my

Abstract: As cyber physical systems (CPS) has progressed, there are many applications which use CPS to connect with the physical world. Moreover the use of cloud in CPS revolutionizes the way in which information is stored and computed making it applicable to a wide range of applications. On the other hand, it also has questionable concerns over the energy consumed applications due to their explosive expansion. Hence in order to increase the efficiency of energy utilisation in the cloud environment, applications are hosted by virtual machines while resources are managed using virtualized Technology. However Quality of Service remains a challenge that is yet to be properly addressed. Hence a virtual machine scheduling algorithm which is aware of us is used to save energy in the designed CPS. The first step in a proposed work is to formulate the objective of the work. This is followed by using a genetic sorting algorithm to identify the apt Virtual Machine (VM) VM mitigation solution. MCDM (Multiple Criteria Decision Making) and SAW (Simple Additive Weighting) can also be used to pick the app scheduling strategy. Experimental and simulation results are observed and recorded based on which concrete conclusions are drawn.

Keywords: Cyber physical systems, virtual machine, Quality of Service, Simple Additive Weighting, Multiple Criteria Decision Making

1. Introduction

In a wide range of enterprises you CPS to incorporate distributed computing in traffic control. A collection of sensors used in this proposed work to gather real time information which is forwarded to computation platforms for processing [1]. The information received is

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

analysed and based on analysis of feedback is generated to the system. This gathered information affects the decision making process. As mobile devices see a significant technological development it is possible to integrate mobile devices and CPS [2] on one platform to obtain more information. The drawback [3] is that CPS requires large computing resources and storage capacity in order to meet their requirements. Hence the limited computing capacity and storage of mobile devices highly effective CPS performance in their respective applications. Cloud computing [4] plays a major role in helping to meet these demands, providing access to a wide range of rich computing resources. Thus it is possible to improve the computing capacity of CPS in applications where the need for resources is maximum. To optimally use available physical resources virtual Technology [5] plays a dominant role to manage available resources in the cloud, making it possible to efficiently manage the cloud platform.

Using virtual machines paves way to low energy consumption and high energy utilisation. Through the aspect of integrating cloud with CPS a number of cloud integrated vehicles are deployed to perform efficiently using the vast resources available in the cloud platform. To provide better service experience [6], it is essential to migrate applications to the cloud by means of reasonable scheduling strategies. Garrison drawbacks include VM migration such as delayed transmission, excessive energy consumption and higher resource necessity [7, 8]. Hence while designing the system it is essential to take into consideration both the positive and negative aspects which might affect the requirements of the users. Energy consumption required for the cloud based CPS will decrease battery life [9] and will also increase the operating cost. Taking these factors into consideration, reduced energy consumption is chosen as the key restricting factor in order to improve user experience when using cloud based CPS. On the other hand, due to the increasing service demands and data traffic, it is quite difficult to meet the requirements of Quality of Service [10]. It is also a difficult task to meet individual users' preferences of QoS on a global platform [11].

Taking these issues into consideration, a VM scheduling method that is QoS-aware is used in this proposed work. In this mechanism, a number of applications that are not of priority and require a larger bank of resources is transferred to another physical machine [12]. This way, some of the workload is transferred out and the server is placed in an energy saving mode of idle condition. By accurately monitoring and balancing offloading [13], it is possible

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

to meet the need for computing resources and improving the QoS of the applications in CPS [14]. In this work, we have introduced a cloud-based CPS with optimal VM scheduling strategy [15-17] to enhance the QoS. Thus an energy conservation mechanism is built as a QoS-aware VM scheduling strategy [18]. The major contributions of the paper are:

- The constraints that are available in the existing methodology [19] are analysed and the basic concepts are defined for the proposed algorithm.
- Optimization of VM scheduling is made possible with non-dominated sorting genetic algorithms to ensure enhancement of QoS [20] along with improvement in resource utilization, downtime and energy consumption.
- Multiple Criteria Decision Making [21] and Simple Additive Weighting [22] is used to choose the most optimal scheduling strategy.
- Experimental evaluation is carried out to determine the effectiveness of the proposed work.

2. Proposed Methodology

2.1 Energy Consumption Analysis

The virtual machines that are used to run the various tasks consume an amount of energy that is represented as AE(X) [23-25]. Here X represents the scheduling policy of the executed task. The active VMs with X scheduling policy that consume AE(X) amount of energy for n^{th} VM [26] can be determined by eq (1):

$$AE(X) = \sum_{n=1}^{N} a_n \theta_n (X). T_m \quad (1)$$

where the running time of CM is $T_n(X)$ [27, 28], energy consumption rate is $a_n(X)$ and θ_n denotes the number of VMs requested. To identify if a p_l is associated with v_n, the binary variable $I_n^l(X)$ is expressed in eq(2):

$$I_n^l(X) = \begin{cases} 1, & if\ x_n = p_l \\ 0, & otherwise \end{cases} \quad (2)$$

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

For an idle VM, the energy consumption is determined using the condition:

$$IE(X) = \sum_{n=1}^{N} \sum_{l=1}^{L} I_n^l(X)\, \theta_n\big(\tau_l(X) - T_N(X)\big).\beta_n(X) \quad (3)$$

where $\tau_l(X)$ represents the running time [29, 30] of the VMs and $\beta_n(X)$ represents the idle mode rate of energy consumption.

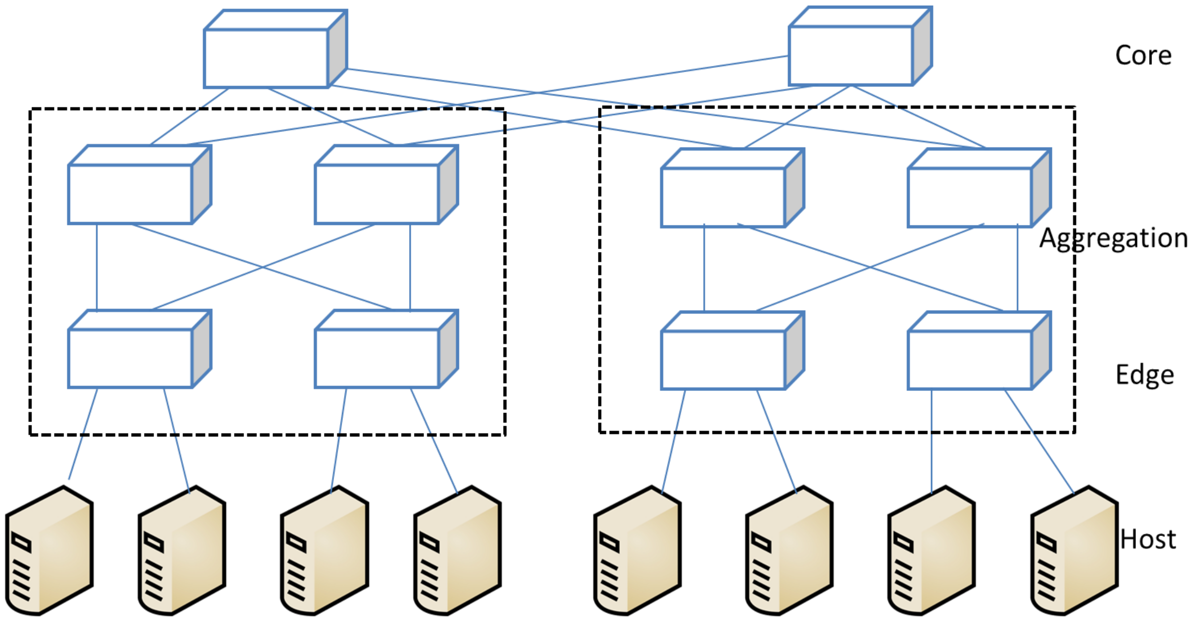

Fig.1. Fat-Tree Topology

Due to the occurrence of network hotspots, the issues of hosts, switches and overloading is determined by the cloud data centre and fat-tree topology. Due to this, the load that cumulates in the core layer is diverted and processed in a timely fashion, leading to the core layer, using a number of links. There are three layers involved in the fat-tree topology namely edge, aggregation and core. Fig.1. shows a fat-tree topology which follows the topology rules:

- K number of ports per switches in the network
- $(\frac{K}{2})^2$ number of core switches

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

- $\frac{K}{2}$ number of aggregate and edge switches inside every pod
- $(\frac{K}{2})^2$ number of connected servers with pods
- K number of pods

2.2 Downtime Analysis

In a typical VM mitigation, access time and switch time of the system is involved. $I_m(X)$ times the memory image is transmitted during the mitigation operation. Let $N_N^{i_N}(X)$ represent the access time of the log files that are remaining. Thus the downtime can be calculated using the formula:

$$N_N^{i_N}(X) = \sum_{n=1}^{N} \sum_{l=1}^{L} I_n^l(X) \,.\, N_N^l(X) . \frac{D_n(X)}{B_{n,l}} \tag{4}$$

The total downtime is calculated using the formula:

$$D(X) = \sum_{i_n=1}^{I_N} N_N^{i_N}(X) + OT_N(X) \tag{5}$$

2.3 ISSM Controller

For scheduling the VM encoding is proposed. A scheduling strategy is used to denote a gene in the genetic algorithm. Groups of genes together form a chromosome that denotes a group of scheduling strategy of VM. Fig.2 shows the encoding schedule for VMs such that at PMs location, V can be represented. Here, migration of v_1 takes place to q_2, v_2 to q_1 and q_N to q_3.

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

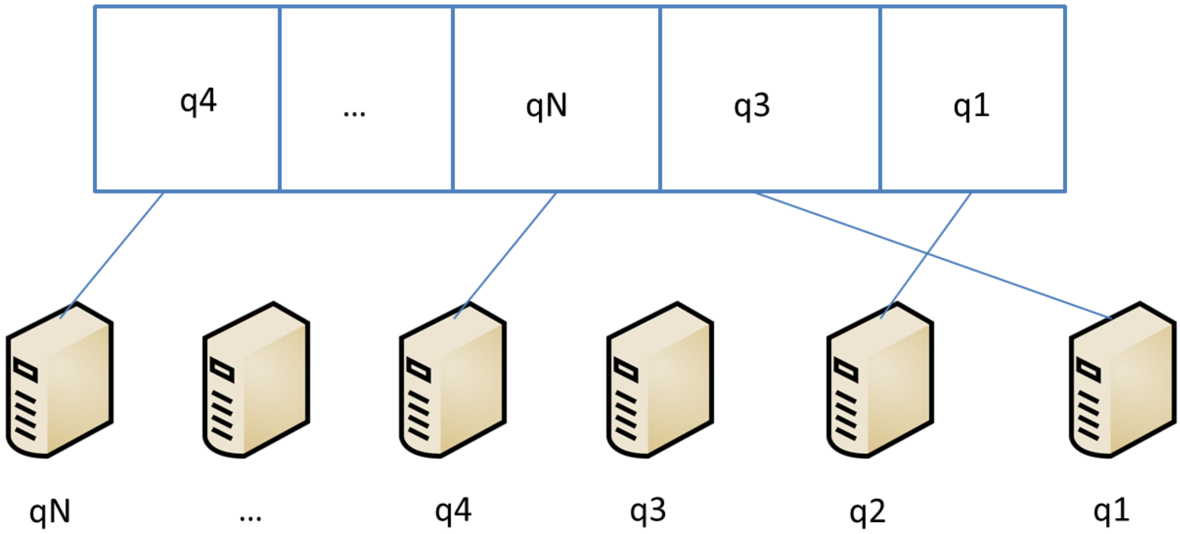

Fig.2. Encoding Schedule for the VMs

2.4 VM Optimization using Hybrid Genetic Algorithm

The GA parameters like the population size are initialized at the start of the program. The parental chromosome is combined at a crossover with respect to the population in order to obtain a spring chromosomes. The possibility of mutation and crossover are represented as C_d and C_C while the iterations can be denoted as I. At the ath schedule, the chromosomes can be represented as:

$$Ch_{a,e} = \{C_{a,e} | 1 \leq a \leq N_p, 1 \leq e \leq N\} \quad (6)$$

The Fig.3 represents a schedule strategy and an instance of its mutation operation.

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

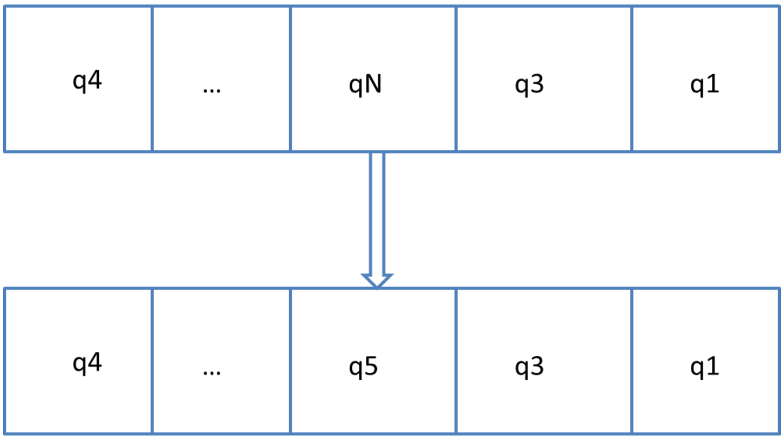

Fig.3. Instance of Mutation

3. Results and Discussion

A comparison is made between the QVMS, ESM and Benchmark to determine the optimal resource utilization based on different application scales. Fig.4 indicates that the proposed methodology is able to attain a more stable and high resource utilization. Hence a significant reduction in the water resources as well the idle VMs can be observed.

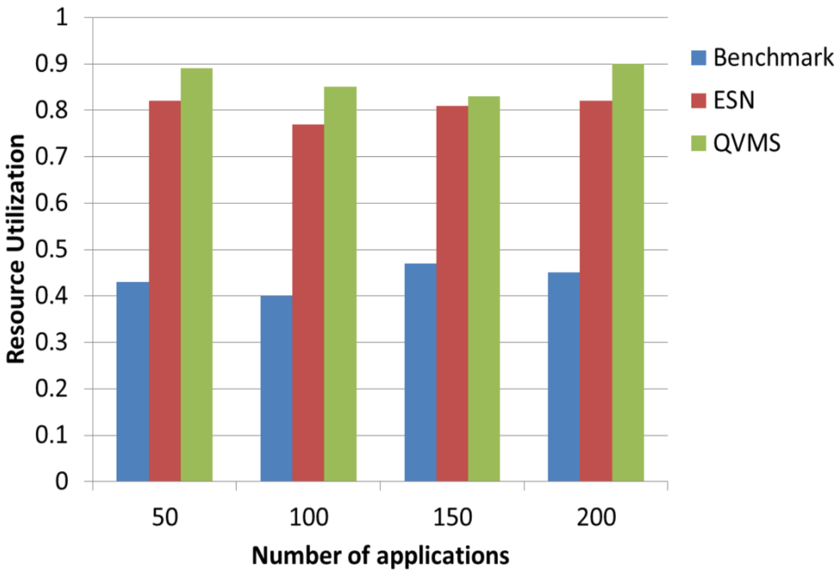

Fig.4. Comparison of Resource Utilization

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

The energy consumption of the proposed methodology is made up of four parts: energy consumption of switches, PMs energy consumption, idle energy consumption and active energy consumption. Fig.5 shows a comparison of the energy comparison in the proposed QVMS, ESN and Benchmark.

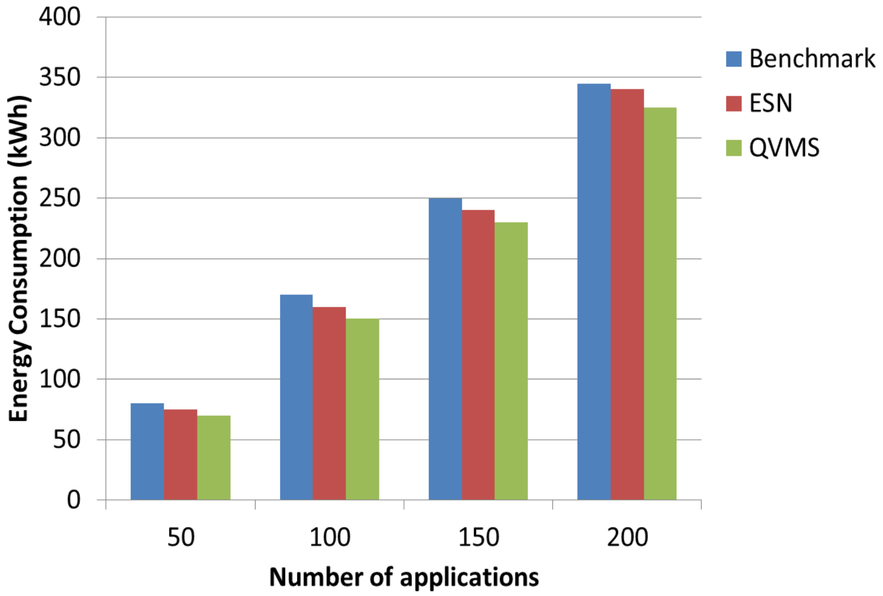

Fig.5 Comparison of Energy consumption

When there are VM migrations, it will not only result in resource utilization, but will also reduce the cost of downtime. A comparative study is made on the cost of downtime for four application scale and it is found that in the Benchmark and ESM, the downtime is longer than that of the proposed QVMS for a fluctuation of 40 seconds in the simulation environment.

4. Conclusion

In this work, a VM scheduling with QoS aware algorithm is used for conservation of energy in a CPS operating on the cloud. A systematic model of the work is laid out with respect to the different parameters involved namely energy conservation, resource utilization and downtime. This model is defined as a multi-objective optimization issue which is solved

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

using the proposed methodology. A comparative study is made on the previously existing methodology and the proposed hybrid genetic algorithm. An optimal scheduling strategy is chosen and is incorporated to decrease energy consumption and downtime and to increase the resource utilization. Experimental analysis and observation indicates the effectiveness of the proposed work. Future work can involve the implementation of more QoS parameters based on the requirements of the user. Moreover, the work carried out can also be implemented in real-life practical scenarios. A comparative note on the methodologies proposed can also be made to identify the best algorithm that is suitable for the application at hand.

References

[1] Manoharan, Samuel, and Narain Ponraj. "Analysis of Complex Non-Linear Environment Exploration in Speech Recognition by Hybrid Learning Technique." Journal of Innovative Image Processing (JIIP) 2, no. 04 (2020): 202-209.

[2] Xia, F., Wang, L., Zhang, D., He, D., & Kong, X. (2015). An adaptive MAC protocol for real-time and reliable communications in medical cyber-physical systems. *Telecommunication Systems*, *58*(2), 125-138.

[3] Adam, Edriss Eisa Babikir. "Deep Learning based NLP Techniques In Text to Speech Synthesis for Communication Recognition." Journal of Soft Computing Paradigm (JSCP) 2, no. 04 (2020): 209-215.

[4] Búr, M., Szilágyi, G., Vörös, A., & Varró, D. (2020). Distributed graph queries over models@ run. time for runtime monitoring of cyber-physical systems. *International Journal on Software Tools for Technology Transfer*, *22*(1), 79-102.

[5] Karuppusamy, P. "Building Detection using Two-Layered Novel Convolutional Neural Networks." Journal of Soft Computing Paradigm (JSCP) 3, no. 01 (2021): 29-37.

[6] Parvin, S., Hussain, F. K., Hussain, O. K., Thein, T., & Park, J. S. (2013). Multi-cyber framework for availability enhancement of cyber physical systems. *Computing*, *95*(10-11), 927-948.

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

[7] Shakya, Subarna, Lalitpur Nepal Pulchowk, and S. Smys. "Anomalies Detection in Fog Computing Architectures Using Deep Learning." Journal: Journal of Trends in Computer Science and Smart Technology March 2020, no. 1 (2020): 46-55.

[8] Lee, J., & Bagheri, B. (2015). Cyber-physical systems in future maintenance. In *9th WCEAM Research Papers* (pp. 299-305). Springer, Cham.

[9] Mugunthan, S. R. "Decision Tree Based Interference Recognition for Fog Enabled IOT Architecture." Journal of trends in Computer Science and Smart technology (TCSST) 2, no. 01 (2020): 15-25.

[10] Musil, A., Musil, J., Weyns, D., Bures, T., Muccini, H., & Sharaf, M. (2017). Patterns for self-adaptation in cyber-physical systems. In *Multi-disciplinary engineering for cyber-physical production systems* (pp. 331-368). Springer, Cham.

[11] Duraipandian, M. "Adaptive Algorithms for Signature Wavelet recognition in the Musical Sounds." Journal of Soft Computing Paradigm (JSCP) 2, no. 02 (2020): 120-129.

[12] Lee, J., Jin, C., & Liu, Z. (2017). Predictive big data analytics and cyber physical systems for TES systems. In *Advances in Through-life Engineering Services* (pp. 97-112). Springer, Cham.

[13] Dhaya, R. "Flawless Identification of Fusarium Oxysporum in Tomato Plant Leaves by Machine Learning Algorithm." Journal of Innovative Image Processing (JIIP) 2, no. 04 (2020): 194-201.

[14] Madhukar, B. N., and S. H. Bharathi. "A New Avenue to the Reciprocity Axioms of Multidimensional DHT Through Those of the Multidimensional DFT." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 119-134. Springer Singapore, 2021.

[15] Adam, Edriss Eisa Babikir, and A. Sathesh. "Construction of Accurate Crack Identification on Concrete Structure using Hybrid Deep Learning Approach." Journal of Innovative Image Processing (JIIP) 3, no. 02 (2021): 85-99.

[16] Yu, B., Zhou, J., & Hu, S. (2020). Cyber-physical systems: An overview. *Big data analytics for cyber-physical systems*, 1-11.

[17] Smys, S., and Wang Haoxiang. "Naïve Bayes and Entropy based Analysis and Classification of Humans and Chat Bots." Journal of ISMAC 3, no. 01 (2021): 40-49.

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

[18] Lee, J., Jin, C., & Liu, Z. (2017). Predictive big data analytics and cyber physical systems for TES systems. In *Advances in Through-life Engineering Services* (pp. 97-112). Springer, Cham.

[19] Smys, S. "A Novel Multi-Tier Architecture Based Mobile Cloud Computing For Enhanced Energy Utilization." Journal of ISMAC 2, no. 01 (2020): 62-72.

[20] Yao, X., Zhou, J., Lin, Y., Li, Y., Yu, H., & Liu, Y. (2019). Smart manufacturing based on cyber-physical systems and beyond. *Journal of Intelligent Manufacturing*, *30*(8), 2805-2817.

[21] Ma, M., Lin, W., Pan, D., Lin, Y., Wang, P., Zhou, Y., & Liang, X. (2018). Data and decision intelligence for human-in-the-loop cyber-physical systems: Reference model, recent progresses and challenges. *Journal of Signal Processing Systems*, *90*(8), 1167-1178.

[22] Shirley, D., Sundari, V. K., Sheeba, T. B., & Rani, S. S. (2021). Analysis of IoT-Enabled Intelligent Detection and Prevention System for Drunken and Juvenile Drive Classification. In *Automotive Embedded Systems* (pp. 183-200). Springer, Cham.

[23] Bordel, B., Alcarria, R., Martin, D., Robles, T., & de Rivera, D. S. (2017). Self-configuration in humanized cyber-physical systems. *Journal of Ambient Intelligence and Humanized Computing*, *8*(4), 485-496.

[24] Janisha, R. S., D. Vishnu, and O. Sheeba. "Frequency Reconfigurable Circular Patch Antenna." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 109-118. Springer Singapore, 2021.

[25] Wan, J., & Xia, M. (2017). Cloud-assisted cyber-physical systems for the implementation of Industry 4.0. *Mobile Networks and Applications*, *22*(6), 1157-1158.

[26] Singh, Akhilesh Kumar, and Manish Raj. "Automated Intelligent IoT-Based Traffic Lights in Transport Management System." In Intelligent Data Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 261-266. Springer Singapore, 2021.

[27] Shirley, D. R. A. (2014, July). Systematic diagnosis of power switches. In *2014 International Conference on Embedded Systems (ICES)* (pp. 32-34). IEEE.

[28] Goswami, Mausumi. "A Document Clustering Approach Using Shared Nearest Neighbour Affinity, TF-IDF and Angular Similarity." In Intelligent Data

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021

Journal of Artificial Intelligence and Capsule Networks (2021)
Vol.03/ No.03
Pages: 218-229
http://irojournals.com/aicn/
DOI: https://doi.org/10.36548/jaicn.2021.3.005

Communication Technologies and Internet of Things: Proceedings of ICICI 2020, pp. 267-276. Springer Singapore, 2021.

[29] Freris, N. M. (2019). A software-defined architecture for control of IoT cyberphysical systems. *Cluster Computing*, *22*(4), 1107-1122.

[30] Raj, Jennifer S. "Improved Response Time and Energy Management for Mobile Cloud Computing Using Computational Offloading." Journal of ISMAC 2, no. 01 (2020): 38-49.

Author's biography

B. Vivekanadam is a senior lecturer in the Department of Computer Science and Multimedia at Lincoln University College, in Malaysia. His major area of research are machine learning, neural network algorithms, image processing, video and signal processing, cloud computing, deep learning, artificial intelligence, object recognition, complex feature extraction and vision graphics

ISSN: 2582-2012 (online)
Submitted: 19.07.2021
Revised: 10.08.2021
Accepted: 21.08.2021
Published: 30.08.2021